MEASUREMENT OF ACHIEVEMENT IN MATHEMATICS

MEASUREMENT
OF
ACHIEVEMENT IN MATHEMATICS

A STATISTICAL STUDY ON EFFECTIVENESS OF BOARD AND UNIVERSITY EXAMINATIONS IN INDIA

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FOREWORD

I have read with interest the study on the MEASUREMENT OF ACHIEVEMENT IN MATHEMATICS undertaken by DR. A. K. GAYEN and others at the Indian Institute of Technology, Kharagpur. If there is one reform which is most urgently needed in our educational system, it is our method of examination. This has been suggested by the various Commissions which have been appointed by the Government of India from time to time.

The present examination system has now been in existence for over a century and has strongly entrenched itself. It is only by focussing the attention of the educationists to the futility of the system and its evil effects on the minds of the youth that we can bring about the desired change. From this point of view, I welcome this study which throws light on the mistakes and shortcomings of the present system. It also makes valuable and concrete suggestions which if carried out will result in a considerable improvement in the present system.

I sincerely hope that this study will prove beneficial to teachers, paper-setters, examiners and educational administrators.

OCTOBER 9, 1961.
MINISTRY OF EDUCATION
NEW DELHI, INDIA

(K. L. SHRIMALI)
UNION EDUCATION MINISTER

PREFACE

The present system of examination and education has been subject to public criticism in our country for the past few decades : Question papers in the examinations conducted by the Boards and the Universities generally measure the power of cramming and not that of real understanding ; they lay more stress on acquisition of information rather than on development of thinking. Often the language in which questions are framed is vague and ambiguous, admitting of various interpretations both by the examinees and by the examiners. There is little evidence of originality, thought or care, in the setting of question papers. Guess-work on probable questions pays rich dividend and encourages cramming. The question papers do not very often take into consideration the area of the prescribed syllabus and the standard of examination concerned. Accordingly, a simple pass, say, by a score of 30 or 36 percent on each subject and the score of 36 percent on the aggregate appears to fall far short of a standard. There is little concordance amongst the examiners in their judgment of the quality of answers. The administration of a large scale public examination of to-day allows innumerable chance errors to operate and gives scope for questioning the validity of such external public examinations ; and so on. These and other wellknown maladies of public examinations led us to gather research evidence upon their root causes and about eight years ago, in 1952, we started our investigations with a post-mortem analysis of the performances of examinees and their assessments by the examiners for the question papers and the syllabi of the year. The reasons for starting our work from this extreme end were that assessments of student performances by the examiners in public examinations serve as the basis of ranking students in order of merit and that the aggregate scores of students are the hall-marks of their abilities in the eyes of both the education authorities and the people at large.

Any improvement of educational standards of students would naturally call for a simultaneous investigation into best ways of reorganising (i) the contents of education, (ii) the methods of teaching and (iii) the methods of examinations. Here we devote ourselves to some studies on examinations only, for it is realised that if there is a single reform in education, it is that of the examination system. Various Commissions and Committees, appointed so far in our country, have emphasized the importance of the role of research in examination reform programmes and a threadbare discussion on the lines of studies and investigations in this regard was recently made in a Seminar on Examinations organised at Bhopal in 1956 by the Ministry of Education. Three years later, in 1959, a Visiting Team of Examination and

Evaluation Experts working in India under an American Educational Exchange Programme recommended that the reform of examination should be based on research evidence collected, not merely through descriptive statistics such as frequency distribution of marks etc., but through correlational study and through the detailed study of the individual question-items set in the existing external examinations (Cieslak, Cowles & Dragositz Report, 1959). We planned earlier some of the above types of studies, and in 1954, we completed a preliminary investigation on Measurement of Achievement in School Final Mathematics, analysing student performances in an examination of the Board of Secondary Education in West Bengal. Based on this preliminary survey we prepared a somewhat long term project for some research on examinations, including in its scope studies on other major subjects of the curriculum, and in the year 1955, we approached the Ministry of Education, Government of India, New Delhi for necessary financial support. The Project was approved in 1956 and the grants from the Ministry were received through the Indian Institute of Technology, Kharagpur.

Secondary Education being the pivot of the entire system from primary to higher, we have selected the School Final Examination as the subject of our study. We have first chosen Mathematics because, as a subject of study, it helps develop mental discipline and as such occupies a unique place in curriculum at all stages of instruction particularly the primary and the secondary. It is a subject in the examination of which subjective factors of examiners play the least significant role, the subject being itself objective in nature. We have taken up the study of achievement in Mathematics of the year 1952, when the Board of Secondary Education was established in West Bengal, and conducted for the first time the School Final Examination, which under the denomination of Matriculation had thitherto been controlled by the University of Calcutta. Sampling techniques were adopted to obtain about four thousand representative answer-scripts out of a total of nearly forty thousand ; relevant factors, such as sex, regional peculiarity, regular and irregular instruction in schools and out-side schools of the candidates concerned, were taken into consideration.

In this investigation our objective has been to suggest in what respect the present system of examination and education should undergo change and improvement. We have made an attempt to study the mistakes and loopholes in public examinations as they are conducted today. For we believe that the study of past mistakes is very essential for bringing about fruitful reforms in the systems of education and examination. The investigation is not a mere analysis of students' performances and examiners' assessments. It has gone a bit deeper to study the structure of the question paper, the appropriateness of question-items from the point of view of their power of discrimination, difficulty value, reliability and validity and finally their relationship with the syllabus and the question paper. In doing these, we have had to evolve new techniques and methods of approach to tackle problems arising in the course of our study of achievements in public examinations now conducted mainly through essay type questions. Comparison has shown that the question papers under survey are typical of those papers which have been set for over a decade in the school final and the matriculation examinations of West Bengal. The question papers in subsequent years, that is 1953 onwards also conform to the same pattern. So we presume that our findings and conclusions, although based upon the performance records of a single year, are sufficiently general and may very well hold good for mathematics examinations of other years also.

We have studied : (*i*) the correlation of internal and external examinations in the secondary stage to determine the validity, (*ii*) the correlation of marks on individual questions with the total marks on the paper of existing external examinations to determine their reliabilities, discriminating powers and difficulty values, (*iii*) the distributions of marks etc., to determine optimum weights, and (*iv*) some conceptual analysis of the syllabus and the question paper. All the four factors of examinations, viz., (*a*) the Syllabus (*What is taught*). (*b*) the Method of teaching (*How it is taught*), (*c*) the Question papers and the Anwer-scripts (*What is examined*), and (*d*) the Method of assessment of candidates' performances (*How it is examined*) are involved in our studies through the analysis of responses in this important subject of the School Final Examination. To be in line with the modern trend in educational research, we have attempted a critical analysis of the syllabus and have tried to find out how far the concepts involved are represented in the question paper under survey.

But we are conscious of the fact that root and branch reform of examinations can hardly be effected unless the entire education process from the formulation of the objectives of education at the beginning to the evaluation of the effects of education at the end are taken into account. So we particularly note that examiners' assessment of students' performances in public examinations, which forms the subject matter of our study, is only one aspect of evaluation which takes into its purview the effect of education on pupils' integrated personality. In the post-independence years, various measures of reform have been suggested by examination and evaluation experts. Educationists of India to-day are becoming more and more evaluation minded, but the whole matter is still going through the laboratory process of research and experimentation, and the vast majority of teachers and students in Indian schools are yet to feel the impact of evaluation ideas in the field. Efforts are however being made by various bodies set up by the Ministry of Education to formulate clearly the aims and objectives of education, and also to discover the drawbacks in the present system of examination in order to build up improved evaluation devices and techniques. A part of this report is devoted to a study of the evaluation concept in education and examinations of the Boards and the Universities. We have made there a survey of examination reform movement in India, and have made an attempt to analyse the aims of examinations, the objectives of education, and the evaluation concept in public examinations. Evidently, evaluation of the education of pupils cannot be fully done through public examinations alone ; internal assessments, cumulative records showing day to day achievements of students appear to be possible methods for finding out the effect of education on all-round development of student personality.

With the publication of *Measurement of Achievement in Mathematics*, we complete the first of a series of studies under the present Project. This Report on Mathematics is based, not so much on descriptive statistics like frequency distributions of marks etc., but largely on correlational studies of marks on the paper and the individual items as well as the marks on different subjects. The Reports on other subjects, namely, English and Bengali for 1957, History and Geography for 1958, Classical Language (Sanskrit) and General Science for 1959, will contain similar correlational studies on the question-items of the papers concerned. Under separate covers we intend to publish certain other studies on examination scores for essay types of question-items using available or freshly developed statistical teehniques as they might be of interest to workers in the fields of psychometry and educational measurements.

We have found many interesting results on problems that are encountered by the workers of Psychometric or Examination Research Units of the Boards and the Universities. Some of our findings may be of particular interest to teachers, paper-setters and examiners and educational administrators who are engaged in bringing about reform in the present system of education and examination of our country. If our work serves some useful purpose in these fields, we shall deem our labour amply rewarded.

SEPTEMBER 1, 1961.
INDIAN INSTITUTE OF TECHNOLOGY,
KHARAGPUR, INDIA

A. K. GAYEN

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MEASUREMENT OF
ACHIEVEMENT IN MATHEMATICS : A STATISTICAL STUDY

PART I

THE FIELD OF INVESTIGATION

1. INTRODUCTION

1.1. The Problem :

The education in schools and colleges of India to-day has been the subject of much public criticism in all its three aspects, namely, (*i*) the contents of education, *i. e.*, the syllabus and the curriculum, (*ii*) the method of teaching, and (*iii*) the system of examinations. A defective system of examination has been dominating the whole field of education, and it has its effect on class-room instructions, as well as on the achievements of candidates. Public attention has repeatedly been drawn, since 1902, to these and other maladies of our system of education by the successive Commissions*. One of the observations of the University Commission (1948) was that 'if we are to suggest one single reform in University education it should be that of examinations.'

The examination as a problem of education is not however peculiar to India only ; it is universal. Many eminent educationists are of the opinion that examinations should be abolished altogether. But there are various practical considerations against this extreme view. It is however admitted that examinations rightly designed and properly conducted could be educationally useful. In fact, if examinations are necessary, a thorough reform of the system is still more necessary.

1.2. Examinations : External and Internal :

Reform of examinations naturally involves the consideration of the two types of examinations that are held to test the achievements of candidates. Some of them are external or public examinations which are conducted by Boards and Universities ; others are conducted by schools and colleges as internal examinations such as, periodical, half-yearly, pre-test and annual. These two types of examinations have two different ends in view. The authorities of large scale public examinations (Boards and Universities) are chiefly concerned with the ranking of candidates on the basis of their achievements measured by a single composite score *i. e.* the grand total of marks of all the subjects of an examination. Here the aim is to determine how far a candidate has learnt the minimum essentials of subjects under the curriculum and how far he will be able to carry on with the same or similar subjects at the next higher stage of education. Technically, this is called the *prognostic* aspect of examinations. It is essentially a merit discrimination test and is sometimes called the general achievement test.

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*The Commissions of the years, 1902, 1917, 1948 and 1951 appointed by the Government of India

In purely internal examinations of schools and colleges, a teacher is less concerned with the achievements of their pupils than with their failures or weak spots in understanding the entire area of a subject. To be more explicit, a teacher wants to know which topics in a particular subject, his pupils have either avoided or have been unsuccessful in their attempts in the examination. The reason is, he wants to make sure that his pupils are fully equipped with the knowledge and understanding of the subject of the curriculum before they sit for the public examination and may deserve good ranking. This is called the *diagnostic* aspect of an examination. A diagnostic test is particularly suitable for class-rooms, since there the objective is to discover the deficiency of candidates in specific subjects with a view to finding out possible remedies. It should be noted that the annual examination of schools or colleges is rather *prognostic* in character, for its principal aim is the ranking of pupils in order of merit.

In spite of their present pre-eminently prognostic character, the public examinations, should have, we think, both prognostic and diagnostic aims. Boards or Universities should not rest satisfied by ranking several thousand candidates, as at present, in a dozen subjects each covering some question papers of two to three hours, and brand them as good, bad or indifferent. To do justice to teachers, to guardians and to students themselves, the examining authorities should take up a diagnostic study of the achievements of all candidates both successful and unsuccessful, so that it would be better for all concerned to know the causes of failure of candidates and to make honest attempts to root out such causes.

1.3. Reform of Examinations :

It is important to note that both the external and the internal examinations are beset with certain obstacles at the present moment which prevent valid and reliable assessment. These obstacles are fundamental in nature and therefore the possibility of standardisation of tests or examinations is very remote. First, a public examination may be looked upon as a series or battery of tests on several different subjects. Again, the students in different types of secondary schools widely vary in their calibre. Moreover, the method of teaching and its efficiency varies from school to school ; qualification and experience of the teaching personnel also vary widely ; the standards of assessment by a large number of examiners are found to be far from uniform because of the fact that the types of questions that are now set in public examinations admit of a large element of subjectivity. The contents of education, namely, the syllabus and the curriculum with their scanty and inadequate phraseology are not intelligible to all concerned with education and examination. Hence it is quite obvious that the judgement on candidates' abilities based upon the assessment of their performances that are influenced by so many chance factors is bound to be erroneous.

As a corrective measure a thorough analysis of all factors of education and examination is urgently necessary. So far as the reform of examinations is concerned, a study of different aspects of question items on different subjects of a public examination along with their corresponding effects on the performances of candidates require a statistical survey and employment of certain statistical techniques to come to a reliable conclusion. It is hoped that if such analysis is continued for several years on a certain public examination, such as the School Final Examination, it would be possible to make a pool (*i. e.* a collection) of really suitable test items (questions) relevant with the syllabus and the curriculum. Then we may have questions on different subjects of somewhat predetermined relative weightages, difficulty values and discriminating powers, validities and reliabilities, in so far as the assessment of abilities of candidates in the examination is concerned. There are regional differences in the syllabus, the curriculum and the standard of teaching in class-rooms and the machinery of examination prevalent in different parts of the country. But it is a fact that with suitable modifications, the line of investigation suggested in the course of this survey may be profitably used by the different Boards and Universities of India which should have their respective Research Units for the purpose.

Reform of traditional examinations started in advanced countries of the world nearly three decades ago. The Secondary Education Commission 1950-51 appointed by the Government of India and the earlier University Commissions recommended research investigations for the improvement of the system of examination in our country.

It is with this background that we took up the statistical survey of the performances of candidates in the School Final Examintation, West Bengal. To start with, we took up the study of achievements in Mathematics* (Compulsory and Additional) of the year 1952, when the Board of Secondary Education established in the State conducted the first School Final Examination, which under the denomination of 'Matriculation' had thitherto been under the control of the University of Calcutta. The considerations which led us to undertake this investigation are : *firstly*, the School Final Examination is at the pivotal stage of the educational system ; *secondly*, Mathematics is a subject in which subjective factors play the least significant part, the matter being by nature somewhat objective ; and *lastly*, in recent years, paper-setting in School Final Examination in general and on Mathematics in particular, has been the subject of much public criticism.

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*The studies on achievements in English, Bengali, Classical Language, History, Geography, etc., of the School Final Examination, West Bengal have since been undertaken.

The present statistical survey was taken up also with the objective of exploring the possibilities of a healthy and wholesome change in the nature of setting questions in public examinations in general and School Final examinations in particular. Our endeavour has simply been to touch the fringe of educational research on these lines. We believe surveys of this nature conducted for other subjects in this and other examinations will reveal valuable information about relationship among (*i*) what is taught (syllabus and curriculum), (*ii*) how it is taught, (instruction in class-rooms) and (*iii*) what is examined (structure of question papers) and (*iv*) how it is examined (method of assessment). All this information will no doubt go a great way to determine the validity and the reliability of our public examinations.

The application of Statistics in educational research is a little more than a quarter of a century old in western countries. In India, statistical methods have not yet been applied to any appreciable extent beyond the laboratory stage of investigations in the fields of education and psychology, *i. e.* in problems on educational and mental measurement, standardization of achievement tests, objective or vocational guidance tests, etc. The reason is not far to seek. In spite of rapid spread of education in all its forms in recent years the fact remains that nearly seventy five percent of the population are not yet literate ; it is also felt that the present system of education is defective and requires a thorough change. So there is hurry and haste everywhere to bring about changes in education in all its aspects ; namely, the curriculum, the method of teaching, the duration of different stages of education and lastly, the system of holding examinations.

The problem appears to be vast and complex. It requires for its systematic analysis and satisfactory solutions a large number of trained personnel and a considerable amount of money to carry out necessary investigations. The principle of construction of the curriculum, the method of instruction in class-rooms and the syllabus and their bearing on paper-setting in public examinations are beyond our present jurisdiction. In all countries, they are left to a body of experts in education and teaching.

In our survey of performances of School Final candidates in Mathematics, we have purposely kept before us both the *prognostic* and the *diagnostic* aspects of examinations ; *prognostic*, because the examining body as well as the guardians and teachers must know the quality of achievements of the candidates with whom they are concerned ; *diagnostic*, because we like to point out the weak spots, if any, in performances of candidates, in class-room instructions and in setting of question papers. Public instruction can only improve by a careful study of the outcome of such surveys and research investigations.

2. THE SAMPLE

2.1. The Answer Papers :

The number of answer papers under survey is 3,717. They represent four different categories of candidates, namely, (*i*) Boys (Regular), (*ii*) Girls (Regular), (*iii*) Boys (Private), and (*iv*) Girls (Private). It may be noted that in West Bengal, candidates are classified as Regular and Private on the basis of how they receive instructions in different subjects. Those who appear in the examination after completing the School Final course in recognised High Schools are called 'Regular'. Those who receive instructions elsewhere and take the examination, are termed 'Private'. It will be seen later that comparison of performances of these two classes of candidates is an interesting study.

For obtaining this representative sample of candidates, the Stratified Random Sampling method was followed. Each examination centre was taken as a separate stratum. The number of strata, *i. e.* the centres, was found to be very large, 102 to be exact ; and their sizes again varied widely with candidates numbering from 20 to 2000. The distribution of candidates in the aggregate and in the sample according to centres is given in *Appendix–B* : *Table I.*

To collect ten per cent sample of the total number of candidates, ten per cent answer papers were selected at random from each of the centres. That the sampling has been fairly satisfactory may be seen from *Table–1*, given below. It is found that the percentage of failures, passes and distinctions both in the Aggregate and in the Sample agree remarkably well. The three proportions namely, 10.0 per cent failures, 85.5 per cent passes, and 4.5 per cent distinctions in the aggregate (36,305) compare well enough with the corresponding 10.3 per cent failures, 85.4 per cent passes, and 4.3 per cent distinctions in the sample (3,717) taken for our study. [It may be noted that there is discrepancy of a little more than six hundred candidates, between the figures for the Aggregate shown in *Appendix–B* : *Table I* and the *Table–2* of this section. These candidates did not sit for the Examination in this paper on Mathematics].

The figures in *Table–1*, are based on all those papers, of which the marks were posted in the Tabulation Register of the Board of Secondary Education, West Bengal.

One view regarding the method of sampling of a large number of candidates distributed in a large number of centres is that centres with small number of students could be added together to form a single unit, so that all strata could be looked upon as having equal number of candidates from each of which a convenient percentage of samples could be taken. Our opinion on this suggestion is that it would have surely saved some amount of time in selecting samples at the cost of the thoroughness which our method has secured specially with regard to the regional differences among candidates and their abilities.

The present Question Paper in Compulsory Mathematics of which the answer papers were analysed, is found on scrutiny to contain a representative type of Questions which had been current for over a decade in the School Final and the Matriculation Examinations in West Bengal. The questions for the subsequent years of 1953–1957 also conform to the same pattern. So it may be safely presumed that the findings of the study may very well apply to the whole population of candidates of the entire period referred to above. The statistical methods followed for the selection of samples and for subsequent analysis of the data should make us confident about the correctness of our findings and conclusions.

TABLE 1 : *Showing the number and percentage of failures, passes, etc., in Compulsory Mathematics for the Aggregate (36,305) and the Sample (3,717) of candidates in the School Final Examination, West Bengal, 1952.*

		AGGREGATE (36,305)					
No. of Candidates in the Subject		No. of Candidates securing the Marks			Percentages to Total in the class with Marks		
		0 – 29	30 – 79	80 – 100	0 – 29	30 – 79	80 – 100
Boys Regular	29093	2659	25004	1430	9.1	86.0	4.9
Boys Private	5862	835	4904	123	14.2	83.7	2.1
Sub-total	*34955*	*3494*	*29908*	*1553*	*10.0*	*85.6*	*4.4*
Girls Regular	900	45	783	72	5.0	87.0	8.0
Girls Private	450	94	354	2	20.9	78.7	0.4
Sub-total	*1350*	*139*	*1137*	*74*	*10.3*	*84.2*	*5.5*
TOTAL :	36305	3633	31045	1627	10.0	85.5	4.5
		SAMPLE (3,717—Sampling Fraction—10.2 per cent)					
Boys Regular	3122	290	2681	151	9.3	85.9	4.8
Boys Private	463	76	383	4	16.4	82.7	0.9
Sub-total	*3585*	*366*	*3064*	*155*	*10.2*	*85.5*	*4.8*
Girls Regular	97	6	86	5	6.2	88.6	5.2
Girls Private	35	11	24	0	31.4	68.6	0.0
Sub-total	*132*	*17*	*110*	*5*	*12.9*	*83.3*	*3.8*
TOTAL :	3117	383	3174	160	10.3	85.4	4.3

3. THE QUESTION PAPER AND THE SYLLABUS

3.1. The Question Paper :

The Question Paper to which constant reference will be made in the course of our study is reproduced below in toto. It is to be noted that the alternative (*a*) part and (*b*) part of any question are denoted subsequently in our study as (*c*) part and (*d*) part respectively of the same question. Thus the (*a*) and (*b*) parts of each question form the *Either* group, and the (*c*) and (*d*) parts, the *Or* group.

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The figures in the margin indicate full marks. The candidates are required to give their answers in their own words as far as practicable.

1. Simplify : 5

$$1+\frac{1}{1+\frac{1}{1+\frac{1}{3}}}+\frac{3\frac{1}{2}\div 2\frac{1}{2}\times 1\frac{1}{2}}{3\frac{1}{2}\div 2\frac{1}{2}\text{ of }1\frac{1}{2}}\div 5.25$$

2. *Either*, (*a*) Find the least number which when divided by 35 leaves a remainder 25, when divided by 45 leaves 35 and when divided by 55, leaves 45. 5

(*b*) A man lost as much by selling 20 chests of tea at *Rs*. 620 per chest as he gained by selling 25 chests at *Rs*. 692 per chest. What did each chest cost him ? 5

Or, (*a*) A society subscribed *Rs*. 35 14 *as*. 1 *p*. to a charity, each member paying as many pies as there were members in the society. Find the number of members. 5

(*b*) If A does a piece of work in 6 days which B can do in 10 days and C can do in 15 days, in what time will they do it all working together ? 5

3. *Either*, (*a*) Find, by practice, the value of 12 sacks of flour each weighing 3 mds. 27 seers 8 ch. at *Rs*. 10 5 *as*. 6 *p*. per maund. 5

(*b*) A rectangular court 24 yds. long and 16 yds. broad has within it a path of uniform breadth of 2 yds. running around it. Find the area of the path. 5

Or, (*a*) When the income-tax is 7 *p*. in the rupee, a person has to pay *Rs*. 31 4 *as*. more than when the tax was 5 *p*. in the rupee. Find his income. 5

(*b*) A person buys 20 srs. of milk at 9 *as*. 6 *p*. per seer. How much water must he add to it so that he may gain *Re*. 1 10 *as*. by selling the mixture at 9 *as*. per seer ? 5

4. *Either*, A train 110 yds. long overtook a person walking along the lines at the rate of 3 miles an hour, and passed him completely in 9 seconds

afterwards it overtook another person and passed him in $9\frac{3}{8}$ seconds. At what rate was this second person walking ? 10

Or, A person transfers *Rs*. 8,000 stock from 4 per cent Government Securities at $98\frac{5}{8}$ to 6 per cent Municipal Debentures at $131\frac{5}{24}$. Find the alteration in his income, the usual brokerage ($\frac{1}{8}$ per cent) being charged on each transaction. 10

5. *Either*, (*a*) Factorise : (*i*) $2x^2+x-15$; (*ii*) x^4+64 3 + 3

(*b*) Find the L. C. M. of $x^2\,(x^2-4)$ and $x^4+2x^3-8x^2$ 5

Or, (*c*) Find the value of $xy+yz+zx$, when $x+y+z=9$ and $x^2+y^2+z^2=31$ 6

(*d*) Solve : $(a/bx)-(b/ax)=a^2-b^2$ 5

6. *Either*, (*a*) Find the square root of $x^4-2x^3+11x^2-10x+25$ 5

(*b*) If $\dfrac{ay-bx}{c}=\dfrac{cx-az}{b}=\dfrac{bz-cy}{c}$, prove that $\dfrac{x}{a}=\dfrac{y}{b}=\dfrac{z}{c}$ 5

Or, (*a*) If $a+b+c=0$, prove that $a(b-c)^3+b(c-a)^3+c(a-b)^3=0$ 5

(*b*) A number consists of two digits, sum of digits being 5. If 9 be added to the number, the digits are reversed. Find the number. 5

7. Draw the graphs of $x+y=2$ and $x=y$. Measure their angle of intersection, and determine the point where they meet. 9

8. *Either*, (*a*) Shew that any two sides of a triangle are together greater than the third side. 6

(*b*) Shew that the difference of any two sides of a triangle is less than the third side. 6

Or, (*a*) Prove that the triangles on the same base and between the same parallels are equal in area. 6

(*b*) Show that the areas of the four triangles into which a parallelogram is divided by its diagonals are all equal. 6

9. *Either*, (*a*) Prove that the sum of the three angles of a triangle is equal to two right angles. 7

(*b*) One angle of a triangle is twice the sum of the other two angles. Determine the magnitude of the angle. 6

Or, (*c*) Prove that one and only one circle passes through three points not lying on a straight line. 7

(*d*) Hence prove that one circle cannot cut another circle at more than two points. 6

10. *Either*, (*a*) Construct a triangle having given the perimeter and two angles. (Traces of construction only are required). 5

(*b*) Find the locus of the vertices of isosceles triangles standing on a given base. 5

Or, (*c*) In a given circle, inscribe a triangle, equiangular to a given triangle. 10

3.2. The Syllabus : Mathematics (Compulsory Course) :

The syllabus of Compulsory Mathematics on which the question paper was set in the School Final Examination, West Bengal in 1952 is reproduced below. It had been in force for a long time since 1939 Matriculation Examination of the Calcutta University.

The course in Compulsory Mathematics shall include ARITHMETIC (35 marks), ALGEBRA (30 marks), and PLANE GEOMETRY (35 marks).

(a) **Arithmetic :** The Four Simple Rules, Vulgar and Decimal Fractions, Reductions, Extraction of Square Root, Practice, Proportion, Simple Interest. [*Problems more easily solvable by Algebra should not be required to be solved arithmetically.*]

(b) **Algebra :** The Four Simple Rules, Proportion, Simple Equations, Resolution into Factors, Greatest Common Measure, Least Common Multiple, Graphs of Simple Equations.

(c) **Plane Geometay :** PRACTICAL : Bisection of angles and of straight lines. Construction of perpendiculars to straight lines. Construction of an angle equal to a given angle. Construction of parallels to a given straight line. Construction of triangles with given parts. Division of a straight line into a given number of equal parts. Construction of a parallelogram equal to a given triangle and having one of its angles equal to a given angle. Construction of a triangle equal in area to a given rectilineal figure. Construction of a tangent to a circle.

[*Easy extensions of these constructions may be given as problems. Candidates may be required to give the reasons for any particular construction involved in any question. Every candidate is required to provide himself with the following :—A hard pencil, dividers, pencil compasses and a straight ruler showing centimeters and inches*].

THEORETICAL : *Angles at a point :* (i) If a straight line stands on another straight line, the sum of the two angles so formed is equal to two right angles and the converse. (ii) If two straight lines intersect, the vertically opposite angles are equal. *Parallel Straight Lines :* (i) If a straight line, cutting two other straight lines, makes *(a)* the alternate angles equal, *(b)* two corresponding angles equal, *(c)* the interior angles on the same side of the line supplementary, then the two straight lines are parallel, and the converse. (ii) Straight lines which are parallel to the same straight line are parallel to one another.

Triangles and Rectilineal Figures : (i) The sum of the angles of a triangle is equal to two right angles. (ii) If the sides of a convex polygon are produced in order, the sum of the angles so formed is equal to four right angles. (iii) Two triangles are equal in every respect, *(a)* If two sides and the included angle of one triangle are respectively equal to two sides and the included angle of the other, *(b)* If two angles and a side of the one triangle are respectively equal to two angles and the corresponding side of the other. (iv) If two sides of a triangle are equal, the angles opposite to the sides are equal and the converse. (v) Two triangles are equal in every respect, if the three sides of one triangle are respectively equal to the three sides of the other. (vi) Two right-angled triangles are equal in every respect, if they have their hypotenuses equal and one side of the one equal to one side of the other. (vii) If two sides of a triangle are unequal, the greater side has the greater angle opposite to it and the converse. *(*viii*)* Any two sides of a triangle are together greater than the third. (ix*)* Of all the straight lines that can be drawn to a given straight line from a given point outside it, the perpendicular is the shortest. *(*x*)* The opposite sides and angles of a parallelogram are equal, each diagonal bisects the parallelogram and the diagonals bisect on another. (xi*)* If there are three or more parallel straight lines and the intercepts made by them on any straight line that cuts them are equal, then the corresponding intercepts on any other straight line that cuts them are also equal.

Areas : (i) Parallelograms on the same or equal bases and of the same altitude are equal in area. (ii*)* Triangles on the same or equal bases and of the same altitude are equal in area. (iii) Equal triangles on the same or equal bases are of the same altitude. (iv) Illustrations and explanations of the geometrical theorems corresponding to the following algebraical identities : $k(a+b+c......)=ka+kb+kc+...$; $(a+b)^2=a(a+b)+b(a+b)$; $a(a+b)=a^2+ab$; $(a+b)^2 = a^2+2ab+b^2$; $(a-b)^2 = a^2-2ab+b^2$; $a^2-b^2 = (a+b)(a-b)$; (v) The square on a side of a triangle is greater than, equal to or less than, the sum of the squares on the other two sides, according as the angle contained by those sides is obtuse, right or acute. The difference in the cases of inequality is twice the rectangle contained by one of the two sides and the projection on it of the other.

Loci : (i) The locus of a point which is equidistant from two fixed points is the perpendicular bisector of the straight line joining the two fixed points. *(*ii*)* The locus of a point which is equidistant from two inter-secting straight lines consists of the pair of straight lines which bisect the angles between the two given lines.

The Circle : *(*i*)* A straight line drawn from the centre of a circle to bisect a chord, which is not a diameter, is at right angles to the chord ; conversely, the perpendicular to a chord from the centre bisects the chord. *(*ii*)* There is one circle, and one only, which passes through three given points not in a straight line. *(*iii*)* In equal circles, (or in the same circle) *(a)* if two chords subtend equal angles at the centre, they are equal ; *(b)* conversely, if two arcs are equal, they subtend equal angles at the centre. (iv) In equal circles (or in the same circle) if two chords are equal, they cut off equal arcs ; conversely, if two arcs are equal, the chords of the arcs are equal. (v) Equal chords of a circle are equidistant from the centre, and the converse. (vi) The tangent at any point of a circle is perpendicular to the radius through the point. (vii) If two tangents are drawn to a circle from an external point *(a)* they are equal, *(b)* they subtend equal angles at the centre of the circle. (viii) If two circles touch, the point of contact lies on the straight line through the centres. (ix) The angle which an arc of a circle subtends at the centre is double that which it subtends at any point on the remaining part of the circumference. *(*x*)* Angles in the same segment of a circle are equal ; and if the line joining two points subtends equal angles at two other points on the same side of it, the four points lie on a circle. *(*xi*)* The angle in a semi-circle is a right angle ; the angle in a segment greater than a semi-circle is less than a right angle ; and the angle in a segment less than a semi-circle is greater than a right angle. *(*xii*)* The opposite angles of any quadrilateral inscribed in a circle are supplementary and the converse. *(*xiii*)* If a straight line touch a circle and from the point of contact a chord be drawn, the angles which this chord makes with the tangent are equal to the angles in the alternate segments. *(*xiv*)* If two chords of a circle intersect either inside or outside the circle, the rectangle contained by the parts of the one is equal to the rectangle contained by the parts of the other.

On the Concurrence of Straight Lines in a Triangle : (i) The perpendiculars drawn to the sides of a triangle from their middle points are concurrent. (ii) The bisectors of the angles of a triangle are concurrent. (iii) The medians of a triangle are concurrent. (iv) The perpendiculars from the vertices of a triangle to the opposite sides are concurrent.

[*Each question on Theoretical Geometry shall consist of a theorem contained in the above schedule together with an easy deduction. Any proof of a proposition shall be accepted, which appears to the Examiners to form part of a systematic treatment of the subject, but proofs of theorems should as far as possible, be based on first principles. The order in which the theorems are stated in the above schedule is not to be regarded as essential. In the proof of theorems and deductions from them, it shall be permissible to use hypothetical constructions. The ordinary symbolical abbreviation may be used*].

4. AIM AND NATURE OF THE SURVEY :

The aim of the survey has been *(a)* to analyse the nature of the present-day paper-setting in the School Final Examination, particularly in Mathematics on the basis of the statistical study on the performances of candidates on each question of the three sections of the paper, namely, *(i)* Arithmetic, *(ii)* Algebra, and *(iii)* Geometry ; and *(b)* to make suggestions for improving the framing of the syllabus, paper-setting and teaching in class-rooms ; *(c)* to help a resourceful teacher of mathematics who may construct suitable sets of questions for class examinations in the light of our findings.

In this study different items of questions on Arithmetic, Algebra and Geometry, have been analysed with an eye to the following points :

(a) Comparison of marks and percentages of failures, passes and non-attempts at various alternatives of a question item.

(b) Study of the grouping of question-items and the balancing of alternatives and their respective weightages.

(c) Comparison of the difficulty value and discriminating power of each question-item in relation to the measurement of ability or achievement of candidates in the subject of Mathematics. How far the score on one particular question-item reflects the total mathematical ability of the student as measured by his total score on the full paper, is also investigated.

(d) Study of relationship of marks in a particular question-item with the total marks on the full paper, jointly and separately for the four categories of candidates mentioned above.

(e) Comparative study of scores on one branch of Mathematics—Arithmetic, Algebra or Geometry, with another and with the total.

For each question, the results of such investigations have been put in tabular forms. (*Appendix–B Tables* : 3-33). In *Tables 2* and *3* below (Section 5) will be seen some figures on number and percentage of attempts, non-attempts, failures, and passes etc., of each question, for 'All candidates'. Such figures for 'Regular' and 'Private' groups of students will be seen in *Appendix–B* with *Tables* 3 to 33, and 34 & 35.

We also intend to study the comparative performances of candidates in different subjects of the School Final Examination including Mathematics.

PART II

THE SURVEY

5. TABULATION OF PERFORMANCES

From the two Tables (*Tables* 2 and 3) the quality and quantity of responses of candidates to each question-item of the whole paper may be known at a glance. The Table 2 shows the number as well as the percentage of candidates in four different situations ; namely, (*i*) Candidates not attempting the question-item (*Col 3*), (*ii*) Candidates who attempted but failed (*Col 4*), (*iii*) Candidates who secured marks between 30 percent to 79 percent of the allotted mark on the question-item (*Col 5*), (*iv*) Candidates who secured 80 per cent marks or above, in the question-item (*Col 6*). In the School Final Examination, West Bengal, candidates securing 80 or above in the 100 mark paper are said to secure Distinction marks ; 30 per cent is the minimum pass mark. Therefore, on a single question-item we have taken 30 per cent of the allotted mark on the item to be the pass mark. The columns 9, 10, 11, 13, 14 and 15 of *Table* 2, show comparisons of percentages of passes and failures etc., on each question-item with reference to (*a*) total number of attempts in the item and (*b*) total number of sampled candidates

In Table 3 is shown the analysis of scores of candidates on each question-item. Here also the qualitative categories already mentioned with regard to Table 2, have been maintained. The aim has been to present a picture of the quality of performances with respect to each question-item. We believe the two tables give all the necessary information about the entire survey and may be of much use and interest to both examining authorities as well as to teachers in class-rooms.

It should be pointed out that there are certain peculiar cases, (Q. 4*a*, Q. 6*b* and Q. 6*c* in which the standard deviation is greater than the mean score. At the first sight it may appear to be absurd. But the nature of the question and the corresponding spread of scores thereon are responsible for these strange results. Question 4*a* is a problem in Arithmetic on Time and Distance. Question 6*b* is a problem in Algebra, on Identity involving Ratio and Proportion. Question 6*c* is a problem on Harder Identity (Cyclic Factorisation). The scores on these problems are so spread that most of the candidates attempting the item secured very low marks resulting in low mean score ; very few secured pass marks or above and thus making the standard deviation higher than the mean score. Because the examining authorities do not certainly envisage negative assessment on an item, the lower range of mark should be taken as zero in these cases.

TABLE 2 : *Showing the number and percentage of attempts on different questions in Compulsory Mathematics of School Final Examination, 1952, for a sample of 3,717 candidates.*

Question Item No.	Short Description of the Question Items	No. of Students (Sample Total : N=3717)				
		Not Attempting	Failing (0—29)	Passing with Marks		Attempting (Total of Cols 4—6)
				30—79	80—100	
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Arithmetic :						
1	Simplification	439	602	7	2669	3278
2 (a)	L. C. M. Problem	2449	295	6	967	1268
(b)	Profit & Loss Problem	3265	187	3	262	452
or (c)	Square-root Problem	1922	177	10	1608	1795
(d)	Time & Work Problem	1600	183	20	1914	2117
3 (a)	Practice	321	513	240	2643	3396
(b)	Fencing & Papering Prob.	1418	725	38	1536	2299
or (c)	Percentage Problem	3539	21	1	156	178
(d)	Alligation Problem	3527	16	0	174	190
4 (a)	Time & Distance Prob.	3584	100	0	33	133
or (c)	Stock & Share Prob.	2573	388	7	899	1294
Algebra :						
5 (a)	Factorisation	955	99	513	2150	2762
(b)	L. C. M. (Algebra)	1610	773	12	1322	2107
or (c)	Identity (Substitution)	2935	72	12	698	782
(d)	Equation	3162	269	2	284	555
6 (a)	Square-root (Algebra)	3499	59	0	159	218
(b)	Ratio & Proportion	3583	99	0	35	134
or (c)	Cyclic Factorization	2837	730	5	145	880
(d)	Equation Problem	1911	352	23	1431	1806
7	Graph Drawing	326	257	973	2161	3391
**Geometry :*						
8 (a)	Theorem 11 (Book I)	393	346	272	2706	3324
(b)	Exercise on Above	2226	798	116	577	1491
or (c)	Theorem 26 (Book II)	3434	29	32	222	283
(d)	Exercise on Above	3616	70	7	24	101
9 (a)	Theorem 16 (Book I)	289	324	267	2837	3428
(b)	Exercise on Above	3247	300	18	152	470
or (c)	Theorem 32 (Book III)	3621	25	14	57	96
(d)	Exercise on Above	3666	32	6	13	51
10 (a)	Triangle Construction	2217	552	80	919	1551
(b)	Locus Finding	3462	122	76	57	255
or (c)	Inscribing a Triangle	3489	91	53	84	228
	FULL QUESTION PAPER :	—	383	3174	160	3717

*Theorems here refer to the text book on School Geometry by Hall & Stevens : Macmillan & Co.

TABLE 2 (*Contd.*) : *Showing the number and percentage of attempts on different questions in Compulsory Mathematics of School Final Examination, 1952, for a sample of 3,717 candidates.*

Question item No.	Percentages to Sample Total (Scores as % of Full Marks on the Item)					Percentage to Total Attempts (Scores as % of Item Full Marks)		
	Not Attempting	Failing (0—29)	Passing with Marks 30-79	Passing with Marks 80—100	Attempting (Total of Cols. 9—11)	Failing (0—29)	Passing with Marks 30—79	Passing with Marks 80—100
(1)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Arithmetic :								
1	11.8	16.2	0.2	71.8	88.2	18.4	0.2	81.4
2 (a)	65.9	7.9	0.2	26.0	34.1	23.2	0.4	76.3
(b)	87.8	5.0	0.1	7.1	12.2	41.4	0.6	58.0
or (c)	51.7	4.8	0.3	43.2	48.3	9.9	0.5	89.6
(d)	43.0	4.9	0.6	51.5	57.0	8.6	1.0	90.4
3 (a)	8.6	13.8	6.4	71.2	91.4	15.1	7.0	77.9
(b)	38.1	19.6	1.0	41.3	61.9	31.5	1.7	66.8
or (c)	95.2	0.6	0.0	4.2	4.8	11.8	0.6	87.6
(d)	94.9	0.4	0.0	4.7	5.1	8.4	0.0	91.6
4 (a)	96.5	2.6	0.0	0.9	3.5	74.6	0.0	25.4
or (c)	69.2	10.4	0.2	24.2	30.8	30.0	0.5	69.5
Algebra :								
5 (a)	25.7	2.7	13.8	57.8	74.3	3.6	18.6	77.8
(b)	43.3	20.8	0.3	35.6	56.7	36.7	0.6	62.7
or (c)	79.0	1.9	0.3	18.8	21.0	9.2	2.5	89.3
(d)	85.1	7.2	0.1	7.6	14.9	48.5	0.3	51.2
6 (a)	94.1	1.6	0.0	4.3	5.9	27.1	0.0	72.9
(b)	96.4	2.7	0.0	0.9	3.6	73.9	0.0	26.1
or (c)	76.3	19.7	0.1	3.9	23.7	83.0	0.5	16.5
(d)	51.4	9.5	0.6	38.5	48.6	19.5	1.2	79.3
7	8.8	6.9	26.2	58.1	91.2	7.6	28.7	63.7
Geometry :								
8 (a)	10.6	9.3	7.3	72.8	89.4	10.4	8.2	81.4
(b)	59.9	21.5	3.1	15.5	40.1	53.5	7.8	38.7
or (c)	92.4	0.8	0.8	6.0	7.6	10.2	11.3	78.5
(d)	97.3	1.9	0.2	0.6	2.7	69.3	6.9	23.8
9 (a)	7.8	8.7	7.2	76.3	92.2	9.5	7.8	82.7
(b)	87.4	8.0	0.5	4.1	12.6	63.8	3.8	32.4
or (c)	97.4	0.7	0.4	1.5	2.6	26.0	14.6	59.4
(d)	98.6	0.9	0.2	0.3	1.4	62.7	11.8	25.5
10 (a)	59.6	14.9	0.8	24.7	40.4	36.8	1.9	61.3
(b)	93.1	3.3	2.1	1.5	6.9	47.8	29.8	22.4
or (c)	93.9	2.4	1.4	2.3	6.1	39.9	23.3	36.8
Full Question Paper :		10.3	85.4	4.3	100.0	10.3	85.4	4.3

TABLE 3 : *Showing the Question-items with the analysis of marks on performances in Compulsory Mathematics of the School Final Examination, 1952, West Bengal, on the basis of a sample of 3,717 candidates.*

Question item No.	Short Description of the Question items	Maximum Mark on the Question (X)	Average Marks secured with S.D. $(\bar{x} \pm s)$	Co-efficient of Variation (C. V.)	Average Marks secured with S. D. in per cent of Maximum Marks of the Questions (Col. 4/Col. 3) 100
(1)	(2)	(3)	(4)	(5)	(6)
Arithmetic :					
1	Simplification	5	4.1 ± 1.9	47.8	81.2 ± 38.7
2 (a)	L. C. M. Problem	5	3.8 ± 2.1	55.3	75.6 ± 41.8
(b)	Profit & Loss Prob.	5	2.9 ± 2.4	84.7	57.6 ± 48.8
or (c)	Squre-root Problem	5	4.5 ± 1.5	33.3	89.4 ± 29.8
(d)	Time & Work Prob.	5	4.5 ± 1.4	31.1	90.4 ± 28.2
3 (a)	Practice	5	4.1 ± 1.8	44.4	81.6 ± 36.2
(b)	Fencing & Papering	5	3.3 ± 2.3	68.9	66.2 ± 45.6
or (c)	Percentage Problem	5	4.4 ± 1.6	36.8	87.4 ± 32.2
(d)	Alligation Problem	5	4.6 ± 1.4	30.3	91.0 ± 27.6
4 (a)	Time & DistanceProb.	10	2.5 ± 4.2	171.5	24.6 ± 42.2
or (c)	Stock & Share Prob.	10	6.8 ± 4.4	65.7	67.6 ± 44.4
Algebra :					
5 (a)	Factorisation	6	5.2 ± 1.6	29.9	86.6 ± 25.8
(b)	L. C. M. (Algebra)	5	3.1 ± 2.4	76.6	62.4 ± 47.8
or (c)	Identity (Substitution)	6	5.3 ± 1.8	32.8	88.8 ± 29.2
(d)	Equation Problem	5	2.6 ± 2.5	97.3	51.3 ± 49.6
6 (a)	Square-root (Algebra)	5	3.6 ± 2.2	60.9	72.6 ± 44.2
(b)	Ratio & Proportion	5	1.3 ± 2.2	168.5	26.0 ± 43.8
or (c)	Cyclic Factorization	5	0.8 ± 1.8	221.7	16.6 ± 36.8
(d)	Equation Problem	5	3.9 ± 2.0	49.7	78.8 ± 39.2
7	Graph Drawing	9	7.0 ± 2.8	39.3	77.7 ± 30.6
**Geometry :*					
8 (a)	Theorem 11 (Book I)	6	5.0 ± 1.9	37.3	82.7 ± 30.8
(b)	Exercise on Above	6	2.5 ± 2.8	110.4	41.5 ± 45.8
or (c)	Theorem 26 (Book II)	6	4.9 ± 1.9	37.9	81.8 ± 31.0
(d)	Exercise on Above	6	1.6 ± 2.4	156.8	25.8 ± 40.5
9 (a)	Theorem 16 (Book I)	7	6.0 ± 2.1	34.2	85.6 ± 29.3
(b)	Exercise on Above	6	2.0 ± 2.7	135.8	33.5 ± 45.5
or (c)	Theorem 32 (Book III)	7	4.6 ± 2.8	60.3	65.6 ± 39.6
(d)	Exercise on Above	6	1.8 ± 2.4	135.4	29.7 ± 40.2
10 (a)	Triangle Construction	5	3.1 ± 2.2	68.7	60.4 ± 43.0
(b)	Locus Finding	5	1.9 ± 1.9	102.1	37.5 ± 38.2
or (c)	Inscribing a Triangle	10	4.8 ± 4.2	87.8	48.3 ± 42.4
FULL QUESTION PAPER :		100	48.1 ±17.3	36.0	48.1 ± 17.3

*Theorems here refer to the text book on School Geometry by Hall & Stevens : Macmillan & Co.

TABLE 3 (*Contd.*) : *Showing the Question-items with the analysis of marks on performances in Compulsory Mathematics of the School Final Examination, 1952, West Bengal, on the basis of a sample of 3,717 candidates.*

Question Item No.	Short Description of the Question items	Average Total Marks with S. D. for Candidates		Average Total Marks with S. D. for Candidates Attempting the Questions
		Failing in the Questions	Passing in the Questions	
(1)		(7)	(8)	(9)
Arithmetic :				
1	Simplification	39.0 ± 15.7	52.7 ± 15.6	50.1 ± 16.5
2 (a)	L. C. M. Problem	37.2 ± 14.2	47.0 ± 15.1	44.7 ± 15.5
(b)	Profit & Loss Prob.	44.9 ± 16.7	56.8 ± 16.6	51.9 ± 17.6
or (c)	Squre-root Problem	41.9 ± 14.4	56.5 ± 15.6	55.1 ± 16.1
(d)	Time & Work Prob.	34.8 ± 15.0	54.5 ± 15.7	52.8 ± 15.9
3 (a)	Practice	37.8 ± 17.3	49.7 ± 15.5	47.9 ± 16.3
(b)	Fencing & Papering	44.3 ± 14.9	56.4 ± 14.8	52.6 ± 15.9
or (c)	Percentage Problem	53.6 ± 18.7	66.9 ± 16.6	65.3 ± 17.4
(d)	Alligation Problem	50.1 ± 15.0	63.8 ± 19.8	62.7 ± 19.8
4 (a)	Time & Distance Prob.	49.2 ± 13.5	66.3 ± 15.4	53.6 ± 16.3
or (c)	Stock & Share Prob.	47.4 ± 12.7	65.7 ± 13.9	60.2 ± 16.3
Algebra :				
5 (a)	Factorisation	28.7 ± 16.3	49.1 ± 15.9	48.4 ± 16.4
(b)	L. C. M. (Algebra)	42.9 ± 14.2	56.0 ± 15.1	51.2 ± 16.1
or (c)	Identity (Substitution)	37.1 ± 15.3	53.5 ± 16.7	52.0 ± 17.2
(d)	Equation Problem	48.8 ± 15.3	63.0 ± 16.4	56.1 ± 17.4
6 (a)	Square-root (Algebra)	45.9 ± 15.2	62.2 ± 15.7	57.7 ± 17.2
(b)	Ratio & Proportion	50.6 ± 17.9	66.5 ± 20.4	54.7 ± 19.9
or (c)	Cyclic Factorization	52.0 ± 16.8	69.1 ± 16.7	54.9 ± 18.0
(d)	Equation Problem	44.0 ± 13.5	58.6 ± 14.7	55.8 ± 15.6
7	Graph Drawing	32.6 ± 15.4	51.1 ± 15.8	49.7 ± 16.5
Geometry :				
8 (a)	Theorem 11 (Book I)	35.5 ± 17.5	50.6 ± 16.0	49.0 ± 16.0
(b)	Exercise on Above	49.1 ± 16.8	63.5 ± 15.9	55.8 ± 17.9
or (c)	Theorem 26 (Book II)	36.6 ± 16.0	48.0 ± 16.2	46.8 ± 16.5
(d)	Exercise on Above	48.1 ± 18.5	66.4 ± 16.2	53.7 ± 19.7
9 (a)	Theorem 16 (Book I)	31.3 ± 14.4	51.0 ± 15.6	49.2 ± 16.6
(b)	Exercise on Above	60.5 ± 16.1	76.5 ± 15.8	66.3 ± 15.0
or (c)	Theorem 32 (Book III)	36.2 ± 12.4	60.3 ± 16.1	54.0 ± 19.7
(d)	Exercise on Above	53.6 ± 17.8	74.0 ± 14.7	61.2 ± 19.4
10 (a)	Triangle Construction	44.8 ± 14.1	59.2 ± 15.8	54.1 ± 16.7
(b)	Locus Finding	60.2 ± 18.6	70.9 ± 16.0	65.8 ± 18.1
or (c)	Inscribing a Triangle	48.3 ± 16.6	68.6 ± 17.0	60.5 ± 19.6
Full Question Paper :		17.6 ± 7.7	51.7 ± 14.4	48.1 ± 17.3

3

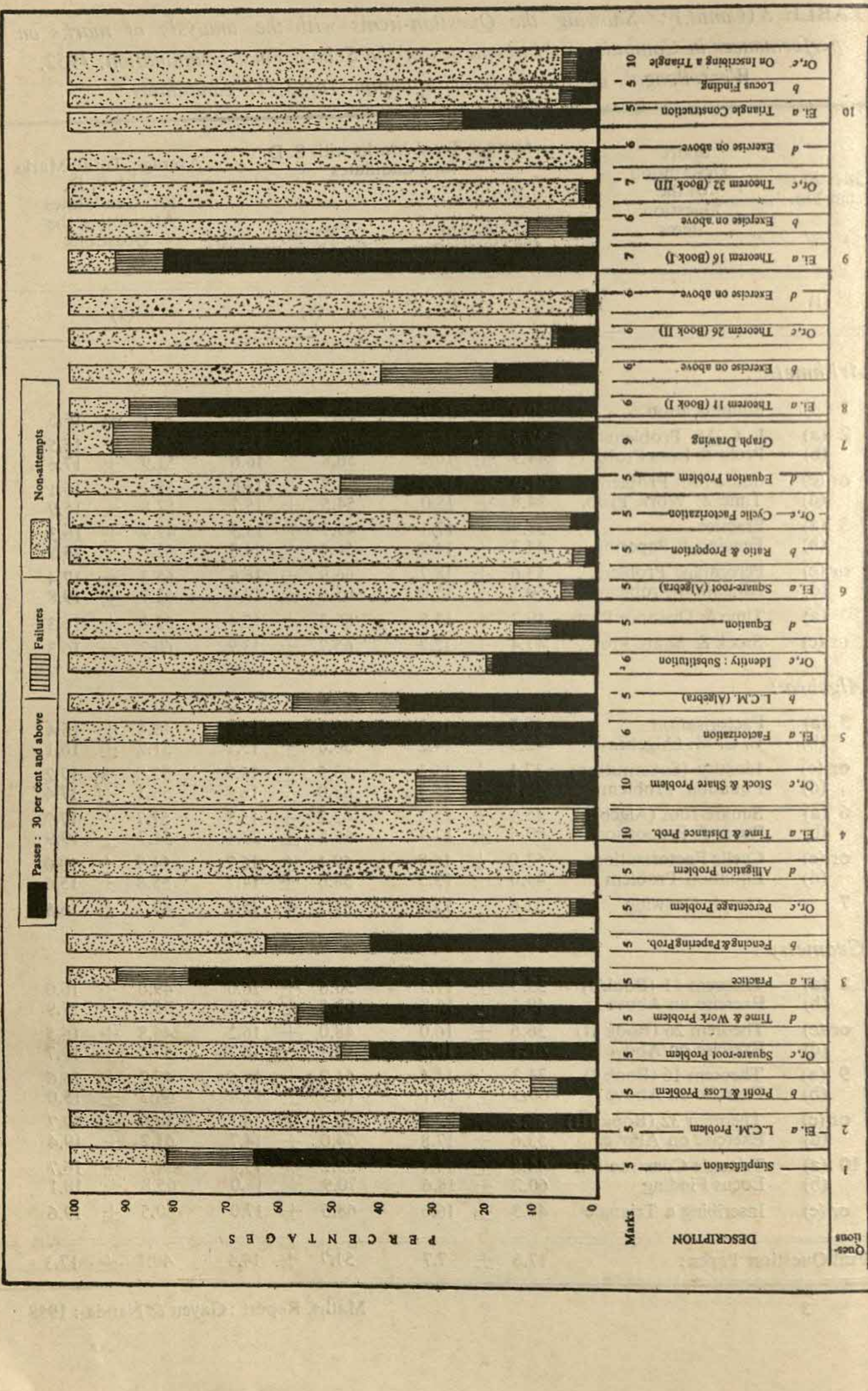

Fig. 1 : Bar Diagram for Percentages of Passes, Failures and Non-attempts in Different Questions of Mathematics (Compulsory) Paper, of the School Final Examination, 1952, West Bengal.

6. SOME CHARACTERISTICS OF THE QUESTION PAPER

The Tables 2 and 3 throw much light on the question paper as a whole as well as on the nature of question-items :

· As high as 90 per cent (89.7 per cent to be exact—*Table* 2) of the total candidates have secured pass marks, that is 30 or above ; only 4 per cent (4.3 per cent) of the total candidates have secured Distinction marks, 80 or above, about 24 per cent (23.8 per cent) candidates secured First Division marks, 60 or above.

It shows the paper was very easy and all but very dull candidates have passed the examination. It appears that the examination does not so much measure mathematical ability as it puts a premium on ordinary mechanical drilling. The Bar diagram shows that in the following questions which together cover 38 marks of the 100-mark paper mechanical drilling rather than real mathematical ability is the source of success and consequent high scores on the items. It is these questions which have been responsible for raising the percentage of passes to as high a point as 90. The questions in point are :

> Q. 1 (Simplification—5 Marks), Q. 3*a* (Practice—5 Marks), Q. 5*a* (Factorisation—6 Marks), Q. 7 (Graph Drawing—9 Marks), Q. 8*a* (Theorem 11, Book I, Geometry—6 Marks) and Q. 9*a* (Theorem 16, Book I, Geometry—7 Marks).

The tabulated results further reveal that the paper enables even a student of Class VII or Class VIII, to the syllabuses of which all the question-items referred to above belong, to secure pass marks and even quite high marks very easily. In fact some of the topics are done even in lower forms of secondary schools. Therefore the question paper seems to be not very suitable for the School Final Examination. Such defective paper-setting is bound to produce an unwholesome effect on the standard of teaching in class-rooms.

Inter-locking of questions by way of alternatives makes the paper rather cumbrous and consumes much time of candidates in the examination hall. How far such inter-locking is justified shall be examined later in the course of this survey. This observation applies to all question-items except Q. 1 and Q. 7 which are single and compulsory items.

Another aspect of the paper deserves mention. The paper contains 31 questions divided into 18 groups of which 10 groups consisting of 16 or 17 individual question-items, a candidate has got to answer to secure full marks. An interesting feature is that the question-items have been so grouped and alternatives have been so arranged that a candidate can select these 16 or 17 individual items in as many as 256 different ways to cover the paper.

Thus a considerable portion of his three allotted hours, a candidate will have to devote to catch a choice of his own out of this bewildering mesh of alternatives.

In the process of marking the answer papers when they are very large in number (the number of School Final candidates in West Bengal really increased from about 37,000 in 1952 to over 100,000 in 1958), such a system of paper-setting is bound to create unnecessary complications and inconvenience which may contribute considerably to heterogeneity in the standard of assessment. That confusion and irritation of examiners resulting from complex arrangement of question-items produce bad effects on markings of answers is a well known psychological truth. Hence, a good arrangement of questions in a paper in public examinations is a matter which should deserve very careful consideration of the examining authorities. As the aim of public examinations is the measurement of ability of candidates, the machinery employed for the purpose should be easy to operate and should be the least complex in all its details. The same view was expressed two years later, by an eminent expert on the Reform of Examinations in India.*

7. PERFORMANCES OF CANDIDATES ON DIFFERENT QUESTION-ITEMS

7.1. Single Compulsory Question-items :

In the previous section we have made certain points on the characteristics of the question paper and on its structure as a whole. Now we proceed to analyse in some detail each and every question-item and performances of candidates thereon. We propose to discuss it under two different heads : Single Compulsory Question-items and Optional but Grouped Question-items.

The question paper shows that the two questions out of 31 are *single* and *compulsory*, namely, Q. 2 on Arithmetic (Simplification) carrying 5 marks, and Q. 1 Algebra (Graph Drawing) carrying 9 marks. We fail to realise the reason why the paper-setter did not set any *compulsory* question-item from Geometry, a branch which covers 35 marks in the 100 mark paper and also why widely different marks have been allotted to these compulsory question-items. Whatever be the reason we think that Geometry has surely been given an unfair deal in this respect.

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* "Even if there were no criticism of the examinations, the *large number of students* taking the Matriculation Examination in India makes it necessary that some changes should be introduced. In 1937, only about 100,000 students took the external examination at the end of the secondary stage, while in 1955-56 it was about 800,000 and undoubtedly this number will increase in the future. Unless technical modifications are carried out to make the examinations *easier to administer*, *grade* and *report*, the administrative machinery necessary to provide for the external examinations will become more and more costly and difficult to maintain".

—Dr. BENJAMIN BLOOM, the Chicago University Expert on Examinations, in a Symposium Lecture (1957), under the auspices of All India Council for Secondary Education, and Ministry of Education, New Delhi.

Now coming to the nature and quality of these two single question-items we find that Q. 1 on simplification involves some fundamental arithmetical operations on fractional and decimal quantities. This question is apparently found to be a good discriminator of mathematical ability in as much as the relationship of the scores on this question and the scores on the whole paper is found to be close. To be explicit, students securing poor marks in the aggregate are found to secure poor marks in this question as well. But strangely enough, percentage of candidates securing full marks in this question is as high as 80. This makes setting of this question rather unimportant, although it is a fact that the percentage of passes (30 and above) on the total score is as high as 89.7. Almost every candidate who secures 30 and above in the total, secures above 80 percent in this question. The item being a compulsory one, it seems that the paper-setter might have in his mind the mechanical way of attaining a certain percentage of passes among the candidates without any reference to measurement of their mathematical ability. In this question which involves mechanical drilling, private candidates have fared definitely worse than regular candidates, thereby showing that schooling does have a considerable effect on the ability of candidates in tackling questions of this type (*Appendix B* : *Table 3*). From the same table it might appear that the Regular Girl students have better aptitudes for such sums. But the observation would be a hasty one, owing to the fact that only a section of Girl candidates offers Compulsory Mathematics in lieu of which there is a separate subject, Domestic Hygiene and Arithmetic, for Girl students only.

Question 7, is a compulsory one in Algebra on Graph. It has been attempted by 92 per cent candidates of whom 92 per cent have passed and 48 per cent secured full marks (*Appendix-B* : *Table* 22). The question-item appears to be a good discriminator, the scores in the item being closely related to those in the aggregate. In fact this question has been a happy selection and it shows that teachers in class-rooms attach importance to it and compel their pupils to undergo drilling in graph work. The question-item is rather easy, because, as noted above, as high as 48 per cent of the attempted cases are found to secure full marks and the average score on the item is as high as 78 per cent against 48 per cent in the aggregate of the candidates. Thus in point of difficulty, the question on graph is a little less than half difficult as the entire paper. Private students are found to be not less keen in graph drawing, the percentage of their attempts, 88, is not far below the figure for the successful regular candidates.

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7.2. Optional but Grouped Question-items :

Besides the two compulsory and single question-items mentioned above, the other twenty nine problems of the paper are grouped. Out of them, twenty four question-items are tagged in twos for setting as alternative groups in six questions, namely, Q. 2 and Q. 3 in Arithmetic ; Q. 5 and Q. 6 in Algebra ; and Q. 8 and Q. 9 in Geometry. The remaining five questions are set as follows : The Question 4(*a*), on Time and Distance stands as an alternative to Q. 4(*c*) on Profit and Loss in Arithmetic, carrying 10 marks each. The Q. 10(*a*) and (*b*), on triangle construction and locus finding, of 5 marks each, together form an alternative group to a single question-item, Q. 10(*c*), on inscribing a triangle in practical geometry. We propose to investigate into the nature of such grouping and its effects. In the next section (Section 8) balancing of alternatives for these groups will be investigated.

In *Arithmetic*, Q. 2(*a*) and (*b*) are sums on L. C. M. and Profit and Loss respectively. Again Q. 2(*c*) and (*d*) contain a problem on Square-root and on Time and Work. The Q. 3(*a*) and (*b*) are sums on Practice and on Measurement of Area respectively, whereas Q. 3(*c*) and (*d*) include a problem on Percentage and a problem on Mixture.

In *Algebra*, Q. 5(*a*) and (*b*) are on Factorisation and L. C. M. and Q. 5(*c*) and (*d*) are sums on Harder Factor and Simple Equation involving fractions respectively. The Q. 6(*a*) and (*b*) include a sum on Square-root and another on Identity, Q. 6(*c*) and (*d*) are a sum on Identity and a Problem on Simultaneous Equation respectively.

In *Geometry*, Q. 8(*a*) and (*b*) are a Theorem of Book I, and a Rider on the same, whereas Q. 8(*c*) and (*d*) are a Theorem of Book II and a Rider on the same. The Q. 9(*a*) and (*b*) contain a Theorem on Book I and a Rider thereon, whereas Q. 9(*c*) and (*d*) are, a Theorem in Book III and with a Rider on the same.

This grouping of question-items as we pointed out previously is a special feature of the paper. In fact, the whole paper of 31 questions is divided into 16 groups. A question arises : Why this grouping at all ? If three branches of Mathematics are to be treated separately, then only three groups, one for each of the three branches, viz., Arithmetic, Algebra and Geometry would have been sufficient. But that has not been done. The result is that a candidate may safely avoid any two subjects, say Algebra and Geometry to get pass marks if he is confident that he can secure 30 out of 35 in Arithmetic. We think, the ideal grouping would have been to divide the whole paper into three groups with a direction that a candidate must answer a minimum number of questions from every group. There is yet another point to consider. Tagging a problem on L. C. M. with one on Profit and Loss, as in Q. 2(*a*) and (*b*), and balancing the two against a problem on Square-root, locked with a problem on Time and Work, the Q. 2(*c*) and (*d*), have the virtue of making a show of justice. The reason may be that the problems on L. C. M. and Square-root are abstract operational problems, but those on Profit and Loss, and Time and Work are concrete practical problems. In other words, grouping may be justified because of balancing.

In fact, this is a typical example of the system of grouping and balancing followed in setting the whole paper. The result of this grouping may appear to have a checking effect on candidates choosing the simple questions only. But in reality, it produces no such effect at all so far as the percentage of passes is concerned. As we have alreday noted, in this paper 90 per cent students have secured pass marks ; it may be argued that the grouping has prevented the candidates from securing high marks or distinction marks (80 or above) and therefore has helped discriminating candidates of real mathematical ability. That this justification of grouping falls through is evident from the statistical analysis of responses to the components of each group of question-items. The disparity between the number of attempts and successes in respect of components of a group is striking everywhere. It also appears that certain questions with which students were not acquainted at all in their class-rooms are set. Whom does such grouping help ? It helps none. It does not help the candidate to secure marks nor does it help the authorities to measure the mathematical ability of candidates. It creates inconvenience and irritation to the examiners as well. It is therefore better for all concerned to dispense with indiscriminate grouping of items in question papers of public examinations.

8. ON THE BALANCING OF ALTERNATIVE QUESTION ITEMS

8.1. Questions on Arithmetic :

Question 2 includes four problems divided into two groups which are alternative in character, the first group of two is balanced against the second group of two question-items. The (*a*)-part of the question is a problem on L. C. M. and the (*b*)-part, a sum on Profit and Loss. A low percentage (34.1 per cent) of attempt for the (*a*)-part is explained by the fact that students are more concerned with mechanical operation than with concrete problems on L. C. M. Do we ask of the students some judgement in selection ? It is likely that 34.1 per cent of candidates may not have devoted time to read the other questions. Only 12 per cent candidates have attempted the (*b*)-part. Such aversion of a large number of candidates show many things of interest :

(*i*) If all students had attempted this item they would have attempted (*a*)-part and would not have attempted (*c*) and (*d*)-parts, that is the other pair offered as alternative to the first one.

(*ii*) The question-item has been practically unhelpful as it has compelled large percentage of candidates to sacrifice 5 marks quite helplessly.

(*iii*) Taking parts (a) and (b) together we find that 66 per cent have not attempted this group at all, of which 57 per cent have taken the other alternative. It is worth noting that the bunching of two questions with equal weight are of different difficulty values.

From Table 3, it will be seen that average marks of the candidates attempting one set of alternatives are considerably different from marks of those answering the other set. The average scores for Q. 2(*a*) and (*b*), being 3.8, and 2.9 against 4.5 and 4.5 for the group 2(*c*) and (*d*) respectively. The same story is repeated in almost all cases of bunching of alternative groups. We have noted that as many as six questions consist of alternative doublets of the above pattern.

Now Q. 2(*c*) is a sum involving Square Root, and Q. 2(*d*), a problem on Unitary Method (Time and Work). Superficially, the pair of problems in the first group and the pair in the second group looks similar. But on analysis of responses, certain significant features are revealed :

(*i*) As against 34 per cent and 12 per cent of candidates attempting (*a*) and (*b*) respectively, we have 48 per cent and 57 per cent attempts for (*c*) and (*d*) parts, thus the average percentage of attempt being more than double in the case of the second group.

(*ii*) About 68 per cent (67.5 per cent) of those candidates attempting the first group, secured pass marks in this question-item against as high as 90 per cent of candidates of those attempting the second group. In this connexion it should be noted that in assessing the pass mark on a question-item in Mathematics we have not accepted the standard applied to the whole paper namely 30 per cent in aggregate of 100 marks. Instead, we have taken 50 per cent of the allotted mark on the item as the minimum marks for a simple pass. One example will make the point clear. In a question on Arithmetic carrying 10 marks a candidate may be said to secure pass marks if he scores 5 marks or more on the item. Whenever an examiner evaluates a candidate's performance at 2 or 3 out of 10, it should be considered as grace marks because mathematical questions are mostly objective in character and should not admit of splitting of scores.

As 90 per cent of the candidates secured pass marks (30 or more) in the grand total, it is thus obvious that (*c*) and (*d*)-parts of Q. 2 have close relationship with the whole paper in so far as its difficulty is concerned.

Thus in respect of Q. 2 with its two groups taken together we find an unbalancing of alternatives reflected in the responses of candidates. Later in this survey, it will be shown that they are also unbalanced in point of their discriminating powers and difficulty values. The number of non-attempts at this question (Q. 2) is very significant. Nine per cent of total candidates have not touched the question at all. (100.0 - 34.1 - 57.0 = 8.9 per cent, Page 15, Table 2, Col. 12). Again 65.9, 87.8, 51.7 and 43.0 per cent candidates have not attempted Q. 2*(a)*, *(b)*, *(c)* and *(d)* respectively. This large number of non-attempts is due to the fact that all the four component items are concrete problems involving arithmetical principles on which teachers in class-rooms devote less time than on routine arithmetical operations. Thus, the teaching process in class-rooms, the setting of questions for the examination and the performance of candidates in the examination appear to have no relations with one another. The paper-setter should have taken into account the actual teaching process in schools, on the syllabus for the examination, before selecting suitable questions to form such alternatives. It is worth noting however that a large percentage of private candidates (Boys and Girls) are found to be attempting and securing better marks in the rarely attempted problems than the regular students coming through schools. It shows how, in striking contrast with our remarks on Q. 1, the defective schooling has had somewhat adverse effects on candidates' performances. Regular students are found to attempt (*c*) and (*d*)-parts oftener than the private candidates. Private candidates have shown a greater interest in the (*b*)-part, which as we have pointed out, is a very rarely attempted question-item.

In Q. 3, the (*a*)-part is a sum on Practice and the (*b*)-part, a problem on measurement of area, a Fencing and Papering Problem. The former has been attempted by 91 per cent of candidates of whom 85 per cent have secured pass marks, whereas the latter has been attempted by 62 per cent candidates of whom only 68 per cent have secured pass marks. The (*a*)-part requires practice and as such candidates of very low calibre are found to secure good marks ; whereas the (*b*)-part, being a problem, is not only attempted by less number of students but also the percentage of passes is found to be considerably lower. It is to be noticed that nearly 30 per cent (91.4 - 61.9 = 29.5 ; Table 2, Col. 12) candidates who at first were tempted to do the sum on Practice could not attempt at all the problem on Fencing and Papering which forms the (*b*)-part of the group here. The two parts being grouped together, so many students deprived themselves of 5 marks. It may be remarked here that if it had been the aim of the paper-setter to measure mechanical ability in doing a sum on Practice then it would have been much happier if the sum on Practice stood alone as a compulsory question-item, and not grouped with a problem.

Coming to the alternative group, (*c*) and (*d*)-parts of the question, carrying equal marks, we find a problem on simple subtraction and division, (Percentage Problem) coupled with a sum on mixture involving profit and loss, (Alligation Problem). Both these items together are much easier than those of the first group. A remarkable feature about this balancing of groups is that only 5 per cent candidates have attempted the latter and nearly 88 per cent and 92 per cent candidates respectively have secured pass marks in those questions (Table 2, Cols. 14 and 15). It will be shown later in the course of this study that *(a)*, *(b)* and *(d)*-parts of Q. 3, are very bad discriminators, the students of low as well as high calibre doing almost uniformly alike in all these question-items. It is only the (*c*)-part of the question on Measurement of Area which appears to be a good discriminator and might have stood on that account as an independent compulsory question-item.

It is a fact however that any question-item when made a compulsory one, may exclude a certain number of candidates who are unable to attempt it. Therefore the safest course is to prepare a set of questions of different types but of similar difficulty value from which a given number has got to be answered by a candidate. This course, if adopted, will be much more convenient from the view point of examiners also. They would not remember the group, the item number, and the alternatives of a question while examining the answer-scripts and may avoid that irritation which such groupings necessarily create. It is common knowledge that irritation of an examiner has a very direful effect on the fate of examinees.

The Question 4(*a*) is a problem on Time and Distance. It has been attempted by very few candidates (3.5 per cent only), and among them only 25 per cent secured pass marks. It is very significant that nearly 96 per cent of candidates did not touch this question-item at all. The Q. 4(*b*), a problem on Stock and Share is attempted by 34.8 per cent students, (about 10 times the attempts on Q. 4*a*) of whom nearly 70 per cent secured pass marks. The problems on Stock and Share are found to be more frequently practised by both regular and private students. Neither of the alternatives has however been touched by 61.7 per cent (100.0 - 3.5 - 34.8 = 61.7, Table 2, Col. 12) of the total number of candidates. The responses on the full question (Q. 4), particularly the (*a*)-part, are clearly a serious reflection on the perfunctory nature of teaching in class-rooms.

8.2. Questions on Algebra :

The Question 5(*a*), a sum on Factorisation, has been attempted by nearly 74 per cent of the candidates of whom about 96 per cent (18.6 + 77.8 = 96.4, Table 2, Cols. 14 and 15) have secured pass marks. It is grouped with the (*b*)-part, a sum on L. C. M. in Algebra, which has been attempted by 57 per cent candidates of whom 63 per cent have secured pass marks. From the disparity of results in the two parts of the question it is seen that at least 18 per cent (74.3 - 56.7 = 17.6, Table 2, Col. 12) candidates had to sacrifice 5 marks due to grouping. Less frequent attempts at (*b*)-part of the question may be explained by the fact that the sum on L. C. M., being really a problem involving factorisation appeared to the candidates as more difficult than simple factorisation operation, in which success is achieved through a plain application of formulae given in the text books. The alternative group, (*c*) and (*d*)-parts, have attracted much less number of candidates. The (*c*)-part, a sum involving harder factors, (Identity, Substitution) is attempted by only 21 per cent of candidates, of whom 92 per cent have secured pass marks, and the (*d*)-part, a sum on Simple Equation involving fraction, by only 15 per cent of the candidates of whom about 52 per cent have secured pass marks. Observations on bad balancing already made about Q. 2 and Q. 3 of Arithmetic, also apply in this case.

The question Q. 6(*a*) is a sum on Square-root grouped with a problem on Ratio and Proportion which forms the (*b*)-part of the whole question. The two parts have been attempted by only 6 per cent and 4 per cent candidates respectively, and of them 73 per cent and 26 per cent have secured pass marks. Although the scores appear to indicate some discriminating powers for these question-items the small frequency of attempts observed, raises the point about the reliability of the same. In fact, out of 3717 candidates, only 218 candidates have attempted this group. Now on the alternatives again, we do not find a much brighter picture. The (*c*)-part of the question, a problem on Identity involving Cyclic Factorisation, has been attempted by 24 per cent candidates of whom 17 per cent have come out successful. The (*d*)-part, a problem on simultaneous equation of a rather easy type, has been attempted by 49 per cent candidates of whom 81 per cent ($1.2 + 79.3 = 80.5$; Table 2, Cols. 14 and 15) have passed. Accordingly, the linking of these problems, namely (*c*) and (*d*)-parts, in one group as alternative to (*a*) and (*b*)-parts in the other, has not been satisfactory. The first, it may be noted, is a much harder group than the second.

8.3. Questions on Geometry :

The Questions 8(*a*) and (*b*) are respectively a Theorem and a Rider. The Theorem, 'Any two sides of a triangle are together greater than the third side' is attempted by 89 per cent and the percentage of success is 90 per cent of the total attempts. Less number of failures of Regular Girls, and greater number of failures of Private Girls are observed. The discrimination made by this question is good but the high percentage of candidates attempting this question-item and as high as 90 per cent of them attaining pass marks makes this discrimination rather unimportant.

The (*b*)-part of the question-item, a Rider, on the above Theorem has been attempted by as low as 40 per cent candidates of whom again only 47 per cent ($7.8 + 38.7 = 46.5$; Table 2, Cols. 14 and 15) have secured pass marks.

This is a serious reflection on the method of teaching Geometry in class-rooms. It clearly shows that teachers neglect definite directions of authorities given in the prescribed syllabus that 'a Rider allied to a Theorem shall be set as a part of the question'. The idea is that students' power of understanding is never judged from their answers on the question on the Book Theorem ; because sheer cramming, as is observed even in Geometry, may enable them to secure full marks. In the present case, the question of testing calibre or merit has practically been eliminated as 90 per cent of those attempting the Book Theorem have secured pass marks and only a few attempts on the Rider have been successful.

Now in the case of the alternative pair, the (*c*) and (*d*)-parts of Q. 8, we find that the paper-setter has formally kept the balance by selecting a Theorem on the 'equality of triangles' in area (Book II), and a Rider on the same. Although this balancing, apparently stands to reason, it has to be judged from the responses of the candidates. Only 7.6 per cent of the total candidates attempted the Theorem, the (*c*)-part, and 2.7 per cent, the Rider, the (*d*)-part. This poor response may be explained by the fact that a candidate with almost absolute certainty, will not prefer a Theorem in Book II on Equality of Area to a very familiar Theorem in Book I as in the present case, with which they have been acquainted since the earliest stage of their secondary education.

Hence our recommendation is that the Theorems from Book I, should not be ordinarily set in questions of the School Final Examination. But Riders on them may be treated as exceptions as they tend to measure the candidates' understanding of the elementary topics in Geometry. If a timely declaration from the Board of Secondary Education is circulated to all recognised schools to this effect, it may produce very desirable results and the consequent improvement on the method of teaching Geometry in class-rooms. Such a step not only for Geometry but also for the other two branches, Arithmetic and Algebra, if taken, will go a great way to raise the standard of instruction in Mathematics at the secondary stage, with the resultant effect that at the collegiate level the students may not be quite at sea in following lectures on higher mathematics.

In Question 9(*a*), the situation is worse than that in Question 8. Again the students are asked to choose between a Theorem and a Rider of Book I, and a Theorem and a Rider of Book III (on Circles). The responses are, 92 per cent and 13 per cent attempts for (*a*) and (*b*)-parts and 2.6 per cent and 1.4 per cent for (*c*) and (*d*)-parts respectively. Cramming may have helped a large number of students in answering the (*a*)-part, being a very familiar Theorem in Book I.

It is difficult to justify the introduction of such alternative choices before candidates sitting for School Final Examination. Considering these two questions (Q. 8 and Q. 9) on Geometry of the paper, we note that Books II and III of Geometry should be ruled out as an alternative to Book I. The only justification perhaps, as we have already pointed out in connection with some question-items on Arithmetic and Algebra, is to raise mechanically the percentage of passes in the subject without any reference to real measurement of ability.

In Question 10, two small construction problems, (*a*) and (*b*)-parts, carrying 5 marks each from Book II, have been balanced against a rather difficult one from Book-III, the (*c*)-part, carrying 10 marks. The question-items do not appear to come within the reach of a large number of candidates. The (*a*) and (*b*) parts have been attempted by 40 per cent and 7 per cent of candidates respectively, of whom 63 per cent ($1.9+61.3=63.2$; Table 2, Cols. 14 and 15) and 52 per cent ($29.8+22.4=52.2$; Table 2, Cols. 14 and 15) again have secured pass marks.

As in many previous cases, here also the (*b*)-part of the question has been attempted by much less number of candidates. The responses show that the question was meant for candidates of high calibre. It is interesting to note that Girls have shown more aptitude to all these construction problems of the question (although the point is unimportant, in view of good girl-students, taking up Compulsory Mathematics in lieu of Arithmetic and Domestic Hygiene). The setting of such questions for measuring real mathematical ability should be encouraged. But only 228 candidates, that is, about 6 per cent of the total sample, have tried to answer this question-item. Thus a very small percentage of candidates attempting this question indicates that the teachers do not take care to acquaint their pupils with the contents of the syllabus including problems of this nature.

It should be noted however that the above observations would very well apply not only to the question paper of the year under review but also to those of recent years in which the same pattern of setting questions in Geometry, Algebra and Arithmetic might have been followed.

From our studies so far on the effect of balancing of alternative question-items on the basis of the responses of candidates, a few things stand out prominently :

> A pair of alternative question-items of unequal difficulty is the worst thing for candidates. The worst possible arrangement of question-items will occur when alternatives widely varying in difficulty and having no justifiable connection among themselves go in pairs.

If however a paper-setter is bent upon setting alternative questions, the best thing for him is to divide the question paper into several groups, each containing questions of somewhat equal difficulty and belonging to the same branch of the subject. There should be at least three groups, one for each of the three branches, Arithmetic, Algebra and Geometry. In every such group, all questions need not be of equal value. But having assigned the total marks for a group and for its individual items separately, the clear direction for the candidates might be given as '*Choose Questions so as to Cover Total Marks Assigned for the Group*'.

It may be suggested in this connection that some short questions of the objective type which may go to test candidates' thorough understanding of the subject should be introduced, and that these short questions should cover a portion of the marks assigned for each of the branches : Arithmetic, Algebra and Geometry. We have discussed this point in a subsequent section of this report.

Setting of questions for School Final Examination on topics covered in top two classes of the High Schools is strongly recommended. It will help raising the standard of instruction in Mathematics in Schools. University Departments or Institutes which teach various branches of science and technology are at present faced with difficulties because of the lack of mathematical qualifications among their students. The step suggested if undertaken would prove to be very useful for a long-term solution of the problem even with the present syllabus of Mathematics in Schools.

In the following sections, discriminating powers and difficulty values of the question-items will be discussed and it will be shown how glaring disparity exists between almost all the alternative groups of question-items.

PART III

THE QUESTION ITEMS AND THEIR DISCRIMINATING POWERS

9. ON THE APPROPRIATENESS OF A QUESTION-ITEM

At the outset, it must be said that in a public examination, any question-item in which scores of all candidates are equal is useless, as it does not help ranking. This proposition also holds good when all candidates secure full marks on a particular question-item or fail to score or do not attempt the question-item at all. We have seen all such cases arise in the course of our survey. The paper-setters, it may be noted, are not always responsible for such undesirable situations. If candidates in their class-rooms are not informed of, or acquainted with, certain aspects of the syllabus, the remedy lies with the teachers responsible for conducting the classes, and with the supervising authorities.

In the present survey, it is found that a number of question-items have led to a high percentage of success. The cases of some standard theorems in Geometry or certain familiar questions on Algebra and Arithmetic may be cited as examples. These question-items have helped candidates at almost all levels of ability to score high marks in the paper. They do not discriminate between good and bad students. But such questions are useful for testing candidates' thorough acquaintance with the essentials of the subject-matter. Though setting of such questions as enable all candidates to score full marks is not appropriate in an achievement test, yet we think, if the importance of a suitable blending of the diagnostic and the prognostic purposes of paper-setting in public examinations is fully realised, then such question-items will be found not only relevant but also necessary.

Now a question may arise : should the standard theorems in Geometry or certain typical questions on important principles in Arithmetic and Algebra with which all candidates are expected to be familiar, be left out altogether ? Our view in regard to this point is that in any question paper certain very essential topics must be included whether they discriminate between good and bad students or not. But the topics must be so chosen that none but those acquainted with the entire field of the curriculum can secure pass marks through these loop-holes alone. To be explicit, paper-setters in selecting question-items on essentials should not confine themselves to portions of the syllabus covered only in the lower forms (standards) of secondary schools.

In the question paper under survey as well as in those of recent years we observe that the question-items on topics of Mathematics done by students of Classes V, VI, VII and VIII, have been set in the School Final Examinations, with the result that as high as 80 to 90 per cent of candidates have come out successful in Mathematics (Compulsory) paper in spite of their complete ignorance of the topics done in Classes IX and X. It is found that a candidate may come out successful with 40 to 50 per cent marks to his credit by avoiding entirely the portions taught in these top classes of High Schools. Hence our recommendation to the examining authorities is that topics done in top classes only should be included in the Syllabus of Mathematics for the School Final Examination and that the question paper on Mathematics should be set on those topics only. This system is actually followed in cases of Language and other papers and there the candidates are examined finally on topics done in top classes of schools. If the same thing were done for Mathematics, the ranking of successful candidates would have been on a superior level, so far as proficiency in the subject is concerned. We have already discussed this point in connection with our observations on the responses on items of Geometry of the present question paper.

The marks allotted on a question-item by the paper-setter, again, deserve careful scrutiny in the light of responses of candidates and in relation to the total marks on the full paper. The matter relates to the concept of difficulty value of a question-item which is to be estimated on the basis of candidates' correct or incorrect responses, and on the number of non-attempts. In a later section, the problem has been dealt with in detail.

The study of the validity and reliability of question-items in an achievement test which fundamentally differ from the objective type of questions used in standardised tests is a difficult problem of educational measurement. We have taken up this point in a separate section where attempts have been made to estimate the validity and calculate the reliability by suitably dividing the paper into two equal halves.

To sum up : the appropriateness of a question-item refers to several of its aspects :

(*i*) its power of discrimation, that is, how far the responses to the question-item may help examining authorities in ranking the candidates in order of merit or classifying them into several groups of superior and inferior ability.

(*ii*) its difficulty value, that is, the value of the question-item in relation to the whole paper on the basis of the responses of candidates.

(*iii*) its suitability from the view point of the syllabus of the subject for the examination.

(*iv*) its reliability, that is, the consistency with which the question-item and its parallel ones measure the proficiency of the candidates in the subject.

(*v*) its validity, that is, its efficiency to measure the true ability of the candidates in the subject.

The following section is devoted to the study of discriminating powers of the question items of the paper under survey.

10. THE QUESTION-ITEMS : HOW THEY DISCRIMINATE

10.1. The Concept of Discrimination :

From the preceding discussions, it is clear that the most important point about an appropriate question-item is to see how far it distinguishes between good and bad students and how far it helps ranking the candidates in order of merit. This quality of a question-item may be technically called its *Discriminating Power.* The following points may prove helpful for conveying a clear idea about this characteristic of a question :

(i) If all candidates correctly answer a question-item and score full marks on the same, the discriminating power of the question-item is nil. Similarly, if all students obtain zero on the item, its discriminating power will also be zero. Again, if all students secure equal marks on an item the discriminating power of the same is also zero.

(ii) A question-item may be said to possess a high discriminating power at a certain ability level, say, 30 per cent, when all candidates securing marks below 30 on the total, score zero or very poor marks, whereas all others whose aggregates are at 30 or above obtain high marks on the item. A perfect discriminating power of unity for such an item at the ability level 30, would require zero scoring for those obtaining up to 29 in the aggregate and cent per cent marks on the item by candidates whose ability levels are at 30 or anywhere beyond it. Such a perfect case, however, seldom arises even in Mathematics.

(iii) A perfect but negative discriminating power of minus unity for an item at any ability level can likewise be conceived where there is hundred per cent scoring of full marks at lower level of that ability and zero beyond that level. In other words, a question-item has negative discriminating power of -1 at a certain level, when all students above the level fail to score, and all students below the level score full marks on that particular item.

(iv) Thus it is possible that the discriminating power of an item, at different levels on the ability scale, may swing between the two extremes of -1 and $+1$.

The expression ability level, may be explained thus. The mathematical ability of a student is an abstract quality and it is difficult to have a quantitative measure of the same with full justice to an individual under test. The measurement of this ability by his aggregate score on a question paper on the subject, however satisfactory it may be, is only a tentative one. The total score is only an observed indication of his true ability in the subject. However, from the nature of the situation involved we have no other alternative than to accept this observed score on the question paper as a satisfactory measure of his ability. When a group of students of different levels of intelligence and with other individual differences is tested in a School Final examination, certain mechanical contrivances have got to be adopted for measuring their abilities in a subject, as is done for example, by putting a three-hour question paper to the candidates with a view to ranking and classifying them for further collegiate education. A measurement of mathematical ability, under the circumstances, can best be represented by the observed aggregate score on the paper. Although acceptance of aggregate score on the paper as a measure of ability may not be quite satisfactory, yet it is presumed that higher the aggregate of a candidate in the paper, the higher is his ability in the subject and higher is his rank. Thus the ability level is determined by the aggregate score and it lies anywhere between 0 and 100 in a hundred-mark paper.

10.2. The Discriminating Curves : Their Characteristics.

The concept of discrimination and the discriminating power of a question-item, introduced in the previous section, may be studied from a graphical representation of scores. Let us take the x-axis to represent the aggregate score on the 100-mark paper, and the y-axis, to represent the average score on a question-item expressed as percentage of the allotted mark on the item, (*i. e.* the mean item score, assuming 100 as allotted mark on an item). Thus, the x-axis represents the ability levels of candidates from 0 to 100, and the y-axis, the scale of achievement on an item, also from 0 to 100. Both the scales, namely, the ability scale and the scale of item-score are conveniently divided into ten class-intervals such as 0 - 9, 10 - 19,...90–above. The mid-point of such a class-interval on the x-axis is first determined, and then the average score on the item in question for the group of candidates belonging to that particular class-interval is obtained. A point plotted for the proposed graph, is the point of intersection of the two straight lines, one representing the total score and passing through the middle point of a particular class-interval on the ability scale parallel to the y-axis and the other, the average item score parallel to x-axis through that point on the y-axis, which represents the average percentage score on the question-item of the group of candidates belonging to the same class-interval. When ten such points corresponding to the ten class-intervals on the ability scale are plotted and joined, the discriminating graph (see Fig. 2 and Fig. 3) for a question-item is obtained.* It is interesting to note that if a question-item is attempted by none, or all candidates fail to score on the item, the discriminating graph for the item would be the x-axis itself. Again, if all candidates score full marks on the item, the discriminating graph will be a straight line parallel to the x-axis through the point (0, 100). Similarly, if all candidates score equal marks on an item (say 4 out of 10), then the discriminating graph on the item will be a straight line parallel to x-axis through the point (0, 40). But in all the three cases, however hypothetical they may be, the discriminating power is nil, for none of them discriminates between superior and inferior candidates.

As in all the above cases the graphs either coincide with or run parallel to the x-axis, it is obvious that whenever the discriminating curve is coincident with or parallel to or tends to be parallel to the x-axis, the power of discrimination of the item is zero or very insignificant. On the other hand, when the curve is parallel or tends to be parallel to the y-axis, there is sharp discrimination between superior and inferior candidates at that point on the ability scale at which the graph rises or tends to rise parallel to the y-axis. It shows that all who have secured lower marks in the aggregate below that point, have scored low marks or no marks on the item. Not only that, all candidates whose aggregates are anywhere between that point and 100 have secured full marks or high marks on the item.

Steep vertical rise of a discriminating curve at any point, as has been noted above, tells a story of its own. It shows a high degree of discrimination at that ability level from where it rises vertically, parallel to the y-axis. It then strikes a strong line of demarcation between the inferior and the superior groups of candidates below and above that ability level. We shall obtain, later in this section, the different ability levels at which all the thirty-one items of the question paper under survey are found to discriminate. (See Cols. for δ_i in Table 6). The discriminating graphs and their characteristics, of all the thirty-one question-items individually and in groups, have been studied in the Technical Appendix–I, of this Report.

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*The discriminating graph of a question-item could also be obtained as the locus of points ($\bar{x}_i$, $\bar{y}_i$), where $\bar{x}_i$ is the average aggregate score of candidates belonging to the i-th class-interval and $\bar{y}_i$, the average score on the item of the same group of candidates. But the graph presented in this Report is the locus of points (x_{mi}, $\bar{y}_i$), where x_{mi} is the mid-point of the i-th class-interval, $\bar{y}_i$ is the average score on the item of the same group of candidates as before. The comparison of the two such different graphs and the discriminating powers of question-items represented by them would be an interesting study which we propose to undertake in respect of another subject of a School Final Examination.

It should be noted, however, that the absolutely steep rise of a discriminating curve is an ideal situation, and does not really occur very frequently. A look into the thirty-one discirminating curves presented in the Technical Appendix–I, will reveal that the movements of the curves are not generally strictly vertical, but rather slanting in appearance. The reason is that the scores of candidates on some items at all ability levels are so dispersed that they mark a rather *gradually* ascending path of the discriminating curve instead of directly vertical or horizontal movements. What really happens is that the candidates with gradually higher aggregates obtain also gradually higher average score on the item. Uniformity on either respect is not as a rule possible. Had there been no such variations, there would have been two and only two alternative situations. The graph might have travelled, either horizontally that is, directly parallel to x-axis or rise vertically parallel to the y-axis. Such extreme instances have not been observed in respect of any of the items of this paper.

Only in a very few cases, tendency for steepness of the discriminating curves has been found to be quite prominent. Obviously, these items possess high discriminating powers, but almost all of them are found to discriminate at very low ability levels, that is at levels below 30. This shows that such question-items which discriminate at 30 or below, do so quite uselessly beacuse they discriminate not between good and bad, but between bad and bad students, who have mostly got plucked in the examination. Later we shall discuss how it is a serious defect of paper-setting. Taking for granted that an ideal question paper should contain questions which discriminate at all levels, some items even below 30, the proportion of those discriminating at very low levels should be reasonably small. This small proportion of very easy questions again should necessarily be on essential topics of the subject. Although they are successfully done by all and sundry, no paper-setter should neglect questions of this type. In our opinion these easy questions on essential topics of the subject should not cover more than 15 marks of a 100-mark paper and that they should be selected from the topics done in top classes of High Schools.

10.3. Levels of Discrimination and their Significance :

The discriminating graph by itself does not appear to show exactly at what point on the ability scale a question-item discriminates between superior and inferior candidates. To know the particular ability level at which a question-item discriminates, we have to draw one straight line parallel to the x-axis through that point on the y-axis, which is chosen as the success score on the item. This choice may be at 30, 50, 60, 80 or 100 per cent of the allotted mark on the item, which correspond to the four standards of success considered by the examining authorities. The value of x at the point of intersection of this straight line and the discriminating curve may be taken as a *workable measure* of the ability level at which the question-item discriminates. Such points of intersection may be as many as the number of adopted standards of success referred to above. For example, a single question-item may discriminate at five different levels on the ability scale when five different standards of success, as stated above, are taken into consideration.

The significance of a level of discrimination of a question-item is that none whose aggregate score on the full paper lies below that level has been able to attain the standard of success chosen for the purpose. By way of illustration, two typical discriminating curves for two question-items of the paper are given here. One of them discriminates at the ability level of about 30, (Fig. 2) and the other, at about 80, *(*Fig. 3*)*, when the standard of success is considered to be 30 per cent score on the item. At the same time we have shown in these two graphs, how the level of discrimination varies when the standards of success are considered to be at 30, 50, 60 and 80 per cent scores on these items. The point of difference between these two items in respect of their levels of discrimination is that the one which discriminates at 30 per cent ability level is a very easy item and the other which discriminates at 80 per cent level is definitely difficult, because none but very brilliant candidates have been able to score even 30 per cent marks on this question-item (Q. 6*c*). Another point to note is that the Question 6*c*, on Cyclic Factorization is so difficult that even the best group of the 3,717 sampled candidates has not been able to secure more than 65 per cent average marks on this question-item as is indicated by the abrupt ending of the discrimating graph (Fig. 3).

In Table 4, below we have shown the levels of discrimination for all the thirty-one question-items on the basis of standards of success 30, 50, 60, and 80 per cent scores. Wide disparity among levels of discrimination of the same question-item when different standards of success are considered would provide an interesting study. For example, Q. 2*a*, 5*a* and 8*c* on the four standards of success 30, 50, 60 and 80, the corresponding levels of discrimination are 4, 9, 29, 44 ; 4, 9, 19, 39 and 4, 9, 14, 44 respectively. This shows that the level of discrimination, by itself, does not provide the complete picture. It has close relation with the standard of success that is taken into consideration. The two together, namely, the chosen standard of success and the corresponding level of discrimination give a clear idea of the quality of a question-item. The Table further shows how indiscreet has been the age honoured practice of taking 30 per cent marks for a simple pass in Mathematics in the School Final Examination, West Bengal. For instance, a look into the figures presented in Col. 4 of Table 4 (page 40) will reveal that on the basis of 30 per cent success score, as many as twelve question-items, namely, Questions

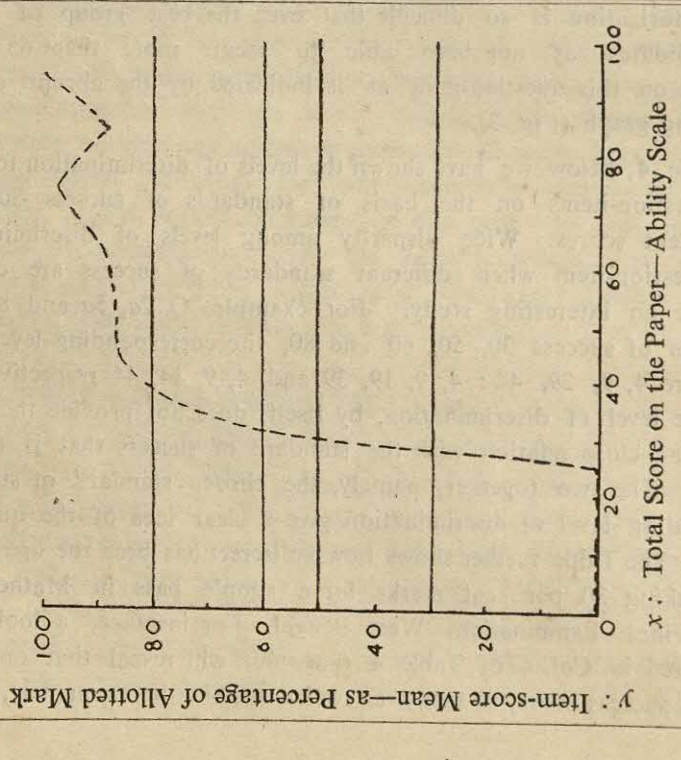

Fig. 2. Discriminating Graph for Q. 3c on Percentage Problem.

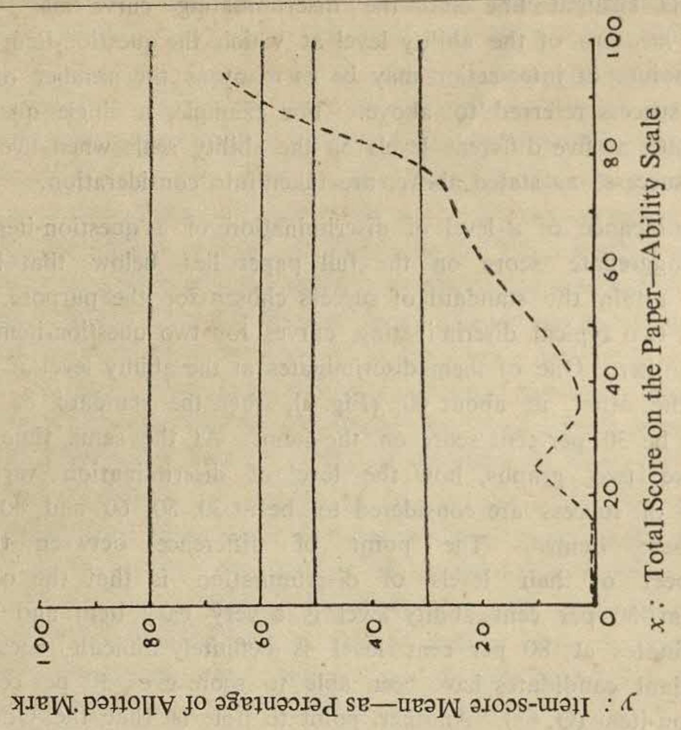

Fig. 3. Discriminating Graph for Q. 6c on Cyclic Factorisation Problem

1, 2a, 2c, 2d, 3a, 3d, 5a, 5c, 7, 8a, 8c and 9a discriminate candidates at levels of 19, 4, 9, 4, 9, 4, 4, 4, 14, 9, 4 and 14 respectively, and they are all plucked candidates. Taking all the various aspects of a public examination, we recommend that fifty per cent scoring in a paper on Mathematics should be accepted as the minimum standard of success.

An important thing to remember in this connection is that it is the level of discrimination which is of greater practical value, rather than the discriminating graph or the discriminating power. By knowing this level of discrimination of a question-item we at once get a clear idea of the difficulty of the item, so far as the sampled candidates are concerned. Whether the curve rises vertically or not, whether the discriminating power is high or low, it is the level of discrimination which tells us exactly where the item discriminates, if it discriminates at all.

10.4. The Discriminating Power and its Measurement :

In the previous section we have discussed how a question-item may discriminate between superior and inferior candidates at different levels of the ability scale. This quality or attribute of a question-item may be termed as its *Discriminating Power*. In the section on concept of discrimination we have shown that the discriminating power of a question-item may in general take an absolute value ranging from zero to unity. Consequently, determination, comparison and therefore measurement of discriminating powers of all the question-items of the paper are necessary.

It has been shown that the discriminating curve of a question-item reflects its discrimating power, and that the intensity of vertical rise of the curve indicates the degree of discrimination. The greater the steepness of the curve, the greater is the discriminating power of the item. For measuring the discriminating power from this steepness of a curve at any level of discrimination on the ability scale, we may apply the following formula :

$$\delta_p = \frac{Y_2 - Y_1}{Y_2 + Y_1},$$

where δ_p denotes discriminating power at any level (say, j-th) of discrimination,

$Y_2 = \frac{1}{(n-j)} \sum_{i=j+1}^{n} \bar{y}_i$, the mean value of item score averages beyond the j-th level ; n being the total number of ability levels considered,

$Y_1 = \frac{1}{j} \sum_{i=1}^{j} \bar{y}_i$, the mean value of item score averages at and below the j-th level.

As we have taken ten class-intervals on the ability scale, the values of i in Y_2 and Y_1 ranges from 1 to 10.

TABLE 4 : *Showing Levels of Discrimination (δ_l) and Discriminating Powers (δ_p) of all the 31 question-items of the paper on Compulsory Mathematics with 30, 50, 60 and 80 as minimum success scores on the item.**

Question Item No.	Short Description of the Question items	s_y' =(S. D. ÷ Alloted Mark)	Values of δ_l and δ_p for success standards of							
			30%		50%		60%		80%	
			δ_l	δ_p	δ_l	δ_p	δ_l	δ_p	δ_l	δ_p
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	Arithmetic :									
1	Simplification	.39	19	.66	29	.51	34	.45	49	.33
2 (a)	L. C. M. Problem	.42	4	.67	9	.34	29	.29	44	.24
(b)	Profit & Loss Prob.	.49	29	.64	44	.50	49	.47	**79**	.36
(c)	Square-root Problem	.30	9	.90	9	.90	14	.74	34	.35
(d)	Time & Work Prob.	.28	4	.75	19	.48	19	.48	34	.34
3 (a)	Practice	.36	9	.68	19	.50	24	.43	39	.29
(b)	Fencing & Papering	.46	24	.71	39	.55	49	.48	**59**	.35
(c)	Percentage Prblem	.32	29	.90	29	.90	34	.84	39	.67
(d)	Alligation Problem	.28	4	.90	9	.90	9	.90	49	.18
4 (a)	Time & Distance Prob.	.42	**69**	.75	**74**	.69	**74**	.69	**89**	.59
(c)	Stock & Share Prob.	.44	39	.73	49	.67	**54**	.62	**64**	.53
	Algebra :									
5 (a)	Factorisation	.26	4	78.	9	.55	19	.36	39	.25
(b)	L. C. M. (Algebra)	.48	29	.69	39	.60	44	.56	**69**	.39
(c)	Identity (Substitution)	.29	4	.75	19	.42	24	.38	39	.27
(d)	Equation Problem	.50	34	.43	**54**	.34	**69**	.49	**79**	.48
6 (a)	Square-root (Algebra)	.44	34	.68	39	.75	44	.67	**64**	.45
(b)	Ratio & Proportion	.44	**79**	.62	**84**	.64	**89**	.66	**94**	.68
(c)	Cyclic Factorization	.37	**74**	.71	**84**	.68	**94**	.65	**94**	.65
(d)	Equation Problem	.39	29	.65	34	.59	39	.52	**54**	.41
7	Graph Drawing	.31	14	.61	24	.49	29	.45	49	.30
	Geometry :									
8 (a)	Theorem 11 (Book I)	.31	9	.53	19	.47	24	.41	39	.27
(b)	Exercise on Above	.46	49	.68	**64**	.61	**69**	.58	**89**	.45
(c)	Theorem 26 (Book II)	.31	4	.80	9	.60	14	.48	44	.19
(d)	Exercise on Above	.41	**69**	.67	**79**	.64	**79**	.64	**94**	.79
9 (a)	Theorem 16 (Book I)	.29	14	.61	19	.55	24	.49	34	.37
(b)	Exercise on Above	.46	**74**	.74	**84**	.72	**84**	.72	**89**	.70
(c)	Theorem 32 (Book III)	.40	29	.89	34	.75	44	.53	**69**	.19
(d)	Exercise on Above	.40	**59**	.82	**79**	.74	**84**	.64	**89**	.53
10 (a)	Triangle Construction	.43	29	.63	44	.53	**54**	.47	**69**	.40
(b)	Locus Finding	.38	**54**	.64	**84**	.46	**84**	.46	**84**	.46
(c)	Inscribing a Triangle	.42	49	.68	**69**	.59	**74**	.56	**76**	.54

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*Levels of discrimination of values greater than 50 and Discriminating Powers 0.75 and above are shown here in bold types for all the four standards of success.

By this formula, we have calculated the Discriminating Power, δ_p, of each of the thirty-one question-items on the basis of 30, 50, 60 and 80 per cent of item-scores, which are the four different standards of success considered. The general symbol, δ_l, has been used to denote the Discriminating Level with reference to any of the standards of success. (See Table 4) : It is obvious that the discriminating power of a question-item or for that matter, the level of discrimination on the ability scale may vary according to the point of success chosen on the y-axis. In the present case, we have chosen (0, 30) as the minimum success point on the item, because the Board of Secondary Education, West Bengal, considers that 30 per cent score on the aggregate of the 100-mark paper on Mathematics should be taken as the minimum pass-mark in the subject. But for reasons stated below it has not been possible for us to rest satisfied at this point. The Board considers four degrees of success in a paper on Mathematics. These degrees correspond to passes in the third division, the second division, the first division and with distinction for which the minimum scores are 30, 50, 60 and 80 respectively.

The fact that in Mathematics part scores on an item should not generally be admissible, deserves consideration. Deduction of marks sometimes has to be made for irregular presentation or for mistakes of minor technical nature but such deductions do not and should not generally exceed twenty to twenty-five per cent of the allotted mark on the item, *i.e.* 1 out of 4 or 5 marks allotted on an item. Whenever it is found that greater deductions have been made and some credit has been awarded by the examiner on a candidate's performance on a question-item in Mathematics, it should be considered as grace marks. For example, if a candidate scores 3 out of 10 by attempting a question-item, it must be admitted that such credit does not refer to the candidate's mathematical ability nor perhaps to his proper understanding of the problem. The examiner in such cases is possibly moved either by some intelligent guesswork on the part of the candidate in approaching the problem or by the diligence shown by him. Therefore from this point of view, it is not reasonable to accept 30 per cent score on an item as the minimum score for a simple pass. It is evident that the same yard-stick can not be applied to measure the success in the aggregate as well as the success on any item of a question paper.

A question may arise : why has 30 per cent score on an item been taken as the score of minimum success in this study ? The reason is that uniformity of measurement has been maintained in cases of both the item-score and the aggregate-score, and this has some justification also. An example may explain this point. In a 100-mark paper consisting of ten questions, each carrying 10-marks, a candidate may score 30 marks only, which may be the sum total of part scores and/or full scores on several question-items of the paper. But this total of 30 marks gives the candidate a distinct status of a pass in the third division which is superior to that of a failure with a total at or below 29 marks.

An altogether different approach to the problem of discrimination of candidates by a question-item may perhaps be provided by a study of the dispersion of scores. A column is given in Table 4 to show the standard deviations of scores adjusted to scale, that is, in units of respective allotted marks of the items. They may be compared with the figures of the discriminating powers corresponding to different levels given in the subsequent columns of the table.

A study of these figures shows that Factorisation (Q. 5*a*) is a very bad discriminator while Equation problem (Q. 5*d*) in Algebra is the best. The figures in some cases reveal that items of high standard deviations discriminate at a high level of ability, that is at 50, 60 and 80. Some of the question-items which discriminate at 30 per cent ability level are found to have low standard deviations ; but the inference does not hold good in many other cases.

If however the overall variance (on which the above standard deviations are based) is resolved into 'within group' and 'between group' components, it may be found that the higher the 'between group' variance, the higher is the degree of discrimination between the two groups. An item may however be said to best discriminate at that ability level which gives rise to maximum 'between group' variance of the item-score for a given value of the overall variance. The ratio of the 'between group variance' to the 'total variance' may be taken as an Index of Discrimination at a particular ability level. This alternative approach to the study of discrimination effected by the question-items, we propose to follow up in detail in the course of our investigation on another subject.

After consideration of the levels of discrimination and the discriminating powers of all the question-items, we should like to study the difficulty values of the items. It will be shown that there may not be any close relation between these two aspects of a question-item, namely, the level of discrimination and the difficulty value. Perhaps it will not be out of place to mention here that these two concepts, by themselves, are entirely different in character. The discriminating power or the level of discrimination is a relative attribute which varies according to the standard of success chosen for consideration. But the difficulty value to which the next section is devoted is a quality of the question-item which does not vary so far as the responses to the item of a given sample of candidates is concerned.

PART IV

THE QUESTION-ITEMS AND THEIR DIFFICULTY VALUES

11. THE DIFFICULTY VALUE OF A QUESTION-ITEM

11.1. The Concept of Difficulty Value :

The difficulty value of a question-item is one of its important qualities by which candidates' ability to respond can be determined. The discriminating power (or the level of discrimination) which has been discussed in the previous section is a somewhat relative attribute of a question-item. It is related to and varies according to the standard of success chosen for consideration. We have already shown how a particular question-item may have a number of discriminating powers corresponding to different levels of discrimination arising out of a number of standards of success; for instance, four standards of success chosen by the examining authorities in West Bengal have given rise to four levels of discrimination and four discriminating powers of each and every question-item.

The difficulty value which we are going to discuss in the present section is a quality of a question-item which has no relation to and does not vary with any standard of success whatsoever, that might be chosen by an examiner. It is related to only one factor, namely, the quality of the examinees involved. If the candidates are gifted, the difficulty value of a question-item would be naturally low as a result of the majority of responses being correct. If, on the other hand, the candidates are of inferior quality, the difficulty value of the same item might be greater, because of majority of incorrect responses. If again the group consists of mediocre candidates, the difficulty value would naturally strike a balance between the two extremes.

If to a question-item responses can be classified as either correct or incorrect, the difficulty value may be conveniently defined as the proportion of incorrect responses, that is the ratio of the number of incorrect responses to the total number of examinees involved. The Difficulty Index thus defined will then swing between zero and unity. It takes the value zero for a very easy item, which all the candidates answer correctly, and the value unity for items which are so difficult that they are successfully attempted by none.

If, however, the responses cannot be strictly classified as correct or incorrect, that is, if there are intermediate scores between zero and the allotted mark, the determination of the difficulty value presents a complex problem. This complexity does not arise in the case of a question-item of the objective type, because responses there must either be fully correct or fully incorrect, and there is no possibility of intermediate scores. In an achievement test of the traditional type the determination of the difficulty value of an item even in a subject like Mathematics is far from simple. The reason is that there is considerable frequency of scores between zero and the allotted mark in respect of almost all the items of the paper. So the problem is : What should be the standard of correctness or incorrectness of responses to an item ? Obviously, zero cannot be the only figure to represent incorrect responses ; on the other hand, fully correct responses are rarely represented by the highest possible score, that is, the allotted mark on the item. To make the matter more complex the examining authorities again consider several different standards of success. For example, candidates scoring 30, 50, 60 and 80 per cent marks of a 100-mark paper are all declared successful, although belonging to different grades of success.

To meet such a situation, the determination of the score which may be taken as a measure of correctness achieved by the candidates as a whole in so far as the responses on an item are concerned, is necessary and such a measure may perhaps be provided by the mean, median or mode of the item-scores. We know that in an achievement test there is no golden rule to accept any fixed score to denote a standard of correctness to which the concept of difficulty value may be related ; so in order to find out a satisfactory standard of correctness in an achievement test, perhaps it is better to strike at a compromise with the concept of correctness associated with an objective test.

Because in an achievement test many intermediate scores occur between zero and the allotted mark on an item, there is perhaps no better way than to accept the average item-score (Mean score) as the starting point in measuring the correctness of responses. If scoring of the full mark on an item represents fully correct response, then it is perhaps most reasonable to say that the ratio of average score to the allotted mark should represent the degree of correctness achieved by the population of candidates concerned. But the difficulty value should normally reflect the degree of incorrectness of the responses to an item. Therefore we may say, that one (unity) minus the ratio of average score to the allotted mark might be taken as a satisfactory measure of the difficulty value of a question-item. An illustration may be given. If the average score of a population of candidates on an item of 10 marks is 4, then the degree of correctness of responses achieved by the population is measured by 0.4 and the difficulty value of the item will be given by $1 - 0.4 = 0.6$.

Another factor which contributes to the complexity of the problem of finding the difficulty value of an achievement test item is the structure of the question paper. If each of all the question-items of a paper is a single and compulsory item, the problem is much easier, for, in all cases, the above mentioned formula will apply. But the structure of the paper under survey is otherwise. Many questions are divided into two alternative groups of two items each. This makes the determination of the average score on each separate item possible in more than one way, since all candidates of the examination are not necessarily involved in responding to each and every question-item of such a paper. The fact is that equally valid reasons can be advanced in support of different relations existing between the number of candidates attempting a particular item and the total number of candidates. The two alternative groups being mutually exclusive such differences are bound to occur. Really, in respect of almost all question papers of all subjects in various examinations of West Bengal setting of alternative questions in some form or other has become prevalent for a long time. Moreover, from available records it is not always possible to determine whether a candidate has secured zero as a result of unsuccessful attempts or he has not attempted the question at all. This gives rise to difficulty in determining the exact number of actual attempts from which the average score may be calculated. Later in this section, we shall discuss that from one point of view, cases of non-attempts on an item may be looked upon as cases of absentees in the examination. At the same time, from another point of view, a case of non-attempt might be considered as a case of zero-score.

11.2. Estimates of Difficulty Values of Question-items :

The difficulty value of an item of the objective type, as we have noted above, can be estimated by the proportion of candidates failing to respond to the question correctly. The formula for its measurement may accordingly be given by,

$$\delta_v = \text{Difficulty Value of an Item} = \frac{\text{Number of incorrect responses}}{\text{Total number of candidates involved}} \quad \ldots \quad (1)$$

$$= 1 - \frac{\text{Number of correct responses}}{\text{Total number of candidates involved}}.$$

In terms of 'successes' and 'failures' this formula may also be expressed by substituting 'failure' for 'incorrect' and 'success' for 'correct' responses.

But this formula, as we have already pointed out, does not apply in the case of an achievement test where there is considerable frequency of intermediate scores between the two extremes, that is zero and the allotted mark.

One may think that to a question-item on Mathematics, responses should be either fully correct or absolutely incorrect. But this is not true in respect of most of the items of the paper under survey. There are certain question-items like Q. 7 on Graph Drawing and Q. 8, Q. 9 and Q. 10 on Theorems and Riders in Geometry where the frequency of scores occurs at almost all points in the whole range of the item-score instead of clustering at its extremes. (See Appendix Tables). Under the circumstances, we define the Index of Difficulty, δ_v, as follows :

$$\delta_v = \text{Difficulty Value of an Item} = 1 - \frac{\text{Average score on the item}}{\text{Allotted mark on the item}} \quad \ldots \quad (2)$$

For items of objective tests, the Index of Difficulty has sometimes been considered to be given by 'the proportion of persons answering each item correctly'. (H. Gulliksen, 1950, p. 385). According to this formula, when all students successfully attempt an item, its difficulty value is unity and when all students fail to respond correctly to an item, its difficulty value is zero. Obviously, the common sense view of difficulty value of an item goes counter to this. Hence to suit our concept of difficulty value we have considered the formulae (1) and (2) above, corresponding to an item of objective and achievement tests respectively.

For many items of the present question paper, except compulsory ones, the problem of knowing the exact number of candidates attempting the items is not simple. In the case of a compulsory question-item, the number of attempts and the number of candidates taking the examination may be said to be the same, since cases of non-attempts may be taken as cases of zero-scores. In the present question paper, Q. 1 and Q. 7 are compulsory and therefore the number of attempts for both the items is taken as 3717, that is, the sampled number of candidates. But for other question-items which are grouped and alternative in character there may be several considerations in determining the number of attempts on each item. We are giving a description of the whole situation by taking Q. 2 as an illustration.

It is a fact that the two events, one of attempting Q. 2*a* and the other of attempting Q. 2*d* are mutually exclusive. Now, the total number of candidates attempting question-items Q. 2*a* and Q. 2*d* is 3385 (1268 for Q. 2*a* + 2117 for Q. 2*d*). Of the remaining 332 (3717 − 3385) candidates, some or all might have approached the Q .2, through its *b*-part or *c*-part or none of them might have attempted the Q. 2, at all. We shall consider the various possibilities of their answering the items Q. 2*b* and Q. 2*c*.

Six different approaches in determining the number of attempts and non-attempts in regard to a particular item may be conceived and all of them have been considered in this survey. As the calculation of the difficulty value of an item involves the average item-score which again depends upon the number of attempts, all the different approaches deserve consideration. It should be pointed out that in calculating average scores, it is sometimes necessary to take cases of non-attempts as cases of zero-scores. For the sake of ready reference, the number of actual attempts on all the four sub-items of Q. 2 is given below :

TABLE 5 : *Showing the Number of Attempts in Q. 2.*

Question Items	Short Description of the Question-items	Number of Attempts
2 Ei (a)	L. C. M. Problem	1268
(b)	Profit & Loss Problem	452
Or (c)	Square-root Problem	1795
(d)	Time & Work Problem	2117

In the first place, if we consider that 452 candidates attempting Q. 2*b* belong to the group of 1268 candidates attempting Q. 2*a*, and 1795 candidates attempting Q. 2*c*, belong to the group of 2117 candidates attempting Q. 2*d*, then the adjustment for the number of attempts is made by adding the remaining 332 candidates to all the four numbers of attempts on the four items Q. 2*a*, Q. 2*b*, Q. 2*c* and Q. 2*d*, because it is evident that the remaining 332 candidates possess no ability to answer any of the four items of the whole Q. 2 (see Method I, Table 6).

Secondly, if we assume that 452 candidates attempting Q. 2*b*, do not all belong to the group of 1268 candidates attempting Q. 2*a*, and also that 1795 candidates attempting Q. 2*c*, do not all belong to the group of 2117 candidates attempting Q.2*d*, then we may plausibly consider that the remaining 332 candidates have been attempting either only Q. 2*b* (and as such Q. 2*a* also) of the 'Either' group (Method II, Table 6) :

Or, thirdly, those 332 candidates attempted only Q. 2*c* (and as such Q. 2*d* also) of the 'Or' group (Method III : Table 6).

Fourthly, it may be noted that the above two assumptions provide for upper and lower extreme number of attempts for each question-item. If we assume that the remaining 332 candidates have been attracted to attempt Q. 2*b* and Q. 2*c* in the same proportion as they have attempted Q. 2*a* and Q. 2*d*, then the adjustment will have to be made with probability proportional to the size of the number of attempts in Q. 2*a* and Q. 2*d* respectively. (Method IV : Table 6).

If, as a fifth alternative, we agree to obtain difficulty values of question-items on the basis of 3385 candidates about whom correct information is available, then the adjusted number of attempts will be equal to the observed number of attempts. Here we take it that 452 candidates attempting Q. 2*b* definitely belong to 1268 candidates attempting Q. 2*a*. Similar is the case of Q. 2*c* and Q. 2*d* (Method V : Table 6).

Lastly, as a sixth alternative, we may assume that since there are two question-items, Q. 2*b* and Q. 2*c* and there are 332 candidates who are asked to attempt any of them, we may take the equal probability estimate that 332 candidates may be equally distributed between these question-items Q. 2*b* and Q. 2*c* of 'Either' and 'Or' groups (Method VI : Table 6).

TABLE 6 : *Adjusted Number of Attempts in Question-items 2a, 2b, 2c and 2d.*

Question Item	Actual No. of attempts	Total No. of candidates	No. of non-attempts	Possible Number of Attempts under Different Situations					
				Method I	Method II	Method III	Method IV	Method V	Method VI
				No. of attempts in (a) and (d) include that in (b) and (c) respectively	No. of attempts in (a) and (d) does not include that in (b) and (c) respectively. 'Either' Case	No. of attempts in (a) and (d) does not include that in (b) and (c) respectively 'Or' case	Adjustment by prob. prop. to size method	On the basis of actual record of attempts	On the basis of probability of 'Equal Chance' for each group
2(a)	1268	3717	332	1268 +332 =1600	1268 +332 =1600	1268 +0 =1268	1268+ 1268/3385 ×332=1392	1268	1268+166 =1434
2(b)	452	3717	332	1268 +332 =1600	1268 +332 =1600	1268 +0 =1268	1268+ 1268/3385 ×332=1392	1268	1268+166 =1434
2(c)	1795	3717	332	2117 +332 =2449	2117 +0 =2117	2117 +332 =2449	2117+ 2117/3385 ×332=2325	2117	2117+166 =2283
2(d)	2117	3717	332	2117 +332 =2449	2117 +0 =2117	2117 +332 =2449	2117+ 2117/3385 ×332=2325	2117	2117+166 =2283

Now we see that under all possible situations the number of attempts for the question-item 2*a* of the 'Either' group varies between 1268 and 1600 and the number of attempts for the question-item 2*d* of 'Or' group varies between 2117 and 2449. If we consider the two extreme numbers of attempts, we shall obtain the lower and the upper limits of difficulty values of the question-items. All other possible approaches give rise to estimates of difficulty values which will necessarily lie between these two limits. For the sake of convenience of comparison, the difficulty values of all the thirty-one question-items obtained through the above six methods are given in a tabular form, (Table 7). It may be seen that the difficulty value of one question-item belonging to any alternative group, when calculated by these methods takes six different values although the differences among them are not always very remarkable.

The determination of the difficulty values naturally leads us to study another interesting aspect of the question-items as well as the question paper as a whole. This aspect refers to the fact that in the light of difficulty values a parallel assessment of the items may be made. Based on a reliable analysis, such a parallel assessment may put to test the allotment of marks by a paper-setter. We choose to call the value of an item so assessed as its 'Optimum Mark' and the mark given to the item by the paper-setter as its 'Allotted Mark', to a comparative study of which the next section is devoted.

11.3. Determination of Optimum Marks of Question-items.

We have utilized estimates of difficulty values of the items, obtained by Method VI (Probability Estimate), described in the previous section, for determination of their respective optimum marks. We define optimum mark of an item to be directly proportional to its difficulty value, the constant of proportionality being the sum total of marks allotted to all the thirty-one question-items of the paper divided by the sum total of estimated difficulty values of all the items. The estimates of optimum marks of question-items thus obtained have been shown in Table 7, of which the Cols. 9 and 10 give the values of the optimum marks and the allotted marks of all the items respectively.

A look at Table 7 reveals that allotment of marks on the question-items is far from satisfactory in a number of cases. The paper-setter has set questions (all the thirty-one question-items) in Arithmetic, Algebra and Geometry carrying 65, 51 and 70 marks respectively, but their corresponding optimum marks are found to be 52, 54 and 80. This indicates that to answer questions of Arithmetic was more profitable for candidates than to answer problems of Geometry. Further, we notice that by a sort of arbitrary grouping of question-items, the paper-setter has put the candidates to a situation involving, as it were, a gamble of chance. The chance factor operates in the course of selection of question-items by candidates who are not usually aware of real weightages (difficulties) of the items they choose to attempt. An illustration will make the point clear.

TABLE 7 : *Showing the Estimates of Difficulty Values of Question-items.*

Question Item No.	Short Description of the Question-item	Difficulty Values (δ_v) by Different Methods						Optimum Marks (Based on Mthd. VI)	Allotted Marks
		I	II	III	IV	V	VI		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Arithmetic :								
1	Simplification	.28	.28	.28	.28	.28	.28	3	5
2 (a)	L. C. M. Problem	.40	.40	.24	.31	.24	.33	3	5
(b)	Profit & Loss Prob.	.84	.84	.79	.81	.79	.82	9 12	5 10
(c)	Square-root Problem	.34	.24	.34	.31	.24	.30	3	5
(d)	Time & Work Prob.	.22	.10	.22	.18	.10	.16	2 5	5 10
3 (a)	Practice	.21	.18	.21	.21	.18	.20	2	5
(b)	Fencing & Papering	.57	.55	.57	.57	.55	.56	6 8	5 10
(c)	Percentage Prblem	.52	.52	.18	.21	.18	.39	4	5
(d)	Alligation Problem	.46	.46	.09	.12	.09	.32	3 7	5 10
4 (a)	Time & Distance Prob.	.99	.99	.76	.91	.76	.98	10	10
(c)	Stock & Share Prob.	.76	.32	.76	.74	.32	.64	7	10
								52	65
	Algebra :								
5 (a)	Factorisation	.19	.14	.19	.18	.14	.16	2	6
(b)	L. C. M. (Algebra)	.55	.52	.55	.55	.52	.54	6 8	5 11
(c)	Identity (Substitution)	.27	.27	.11	.14	.11	.20	2	6
(d)	Equation Problem	.70	.70	.64	.66	.64	.68	7 9	5 11
6 (a)	Square-root (Algebra)	.92	.92	.27	.60	.27	.85	9	5
(b)	Ratio & Proportion	.98	.98	.84	.91	.84	.97	10 19	5 10
(c)	Cyclic Factorization	.96	.92	.96	.96	.92	.94	10	5
(d)	Equation Problem	.59	.21	.59	.57	.21	.46	5 15	5 10
7	Graph Drawing	.29	.29	.29	.29	.29	.29	3	9
								54	51
	Geometry :								
8 (a)	Theorem 11 (Book I)	.20	.17	.20	.20	.17	.19	2	6
(b)	Exercise on Above	.82	.81	.82	.82	.81	.82	9 11	6 12
(c)	Theorem 26 (Book II)	.41	.41	.18	.21	.18	.32	3	6
(d)	Exercise on Above	.93	.93	.91	.91	.91	.92	10 13	6 12
9 (a)	Theorem 16 (Book I)	.19	.14	.19	.17	.14	.17	2	7
(b)	Exercise on Above	.96	.95	.96	.96	.95	.96	10 12	6 13
(c)	Theorem 32 (Book III)	.78	.78	.34	.38	.34	.67	7	7
(d)	Exercise on Above	.95	.95	.84	.85	.84	.92	10 17	6 13
10 (a)	Triangle Construction	.73	.40	.73	.71	.69	.63	7	5
(b)	Locus Finding	.97	.94	.97	.97	.94	.96	10 17	5 10
(c)	Inscribing a Triangle	.95	.95	.52	.77	.52	.91	10	10
								80	70
FULL QUESTION PAPER :		.52	.52	.52	.52	.52	.52		
TOTAL :							17.54	186	186

The marks allotted to the question-items Q. 2*c* and Q. 2*d* are 5 and 5 respectively, but the optimum marks of these question-items calculated from their difficulty values are respectively 3 and 2. Hence it may be said that a candidate who, without any deliberate choice, quite unknowingly hits upon this pair of alternative question-items, was a gainer by a good margin in comparison with the candidate who selected the other pair Q. 2*a* and Q. 2*b*, of which the allotted marks are 5 and 5, but the optimum marks calculated from their difficulty values are 3 and 9 respectively. So it is evident that one who chose and successfully attempted the first pair, Q. 2*a* and Q. 2*b*, worked for 12 marks, but obtained only 10 marks ; whereas some other examinee selecting the second pair, Q. 2*c* and Q. 2*d*, secured 10 marks by working upon the problems worth 5 (3 + 2) marks only. This holds out the injustice done to candidates by balancing two pairs of alternatives—one worth 5 and the other worth 12 marks. Coming to the individual sub-items of Q. 2, we find there is also glaring disparity between their optimum and the allotted marks. The question-item Q. 2*b* which is worth 9 marks is allotted 5 ; on the contrary the question-item Q. 2*d* which is worth 2 marks only, is also allotted 5. So, in a sense, an item of 2 marks is balanced against another of 9 marks.

11.4. Classification of Possible Choices on the basis of Difficulty Values of Question-items.

The determination of optimum marks on the basis of difficulty values of question-items *vis-a-vis* the marks allotted by the paper-setter presents an interesting aspect of the paper. In an earlier section we pointed out that there may be 256 alternative choices for a candidate to select question-items covering one hundred marks. Determination of optimum marks on the basis of difficulty values of items is really a new assessment or re-valuation. Judged by this standard, the weightage of every question-item as well as of the three groups of questions belonging to three sections, Arithmetic, Algebra and Geometry of the question paper on Mathematics, may be said to acquire altogether different values. In other words, in respect of difficulty, the question-items may be said to carry two series of values : one, the marks allotted by the paper-setter and the other, their estimated optimum marks. This we discussed in the previous section.

By a careful examination of the nature of responses to the items of the question paper under study we observe that of the 256 alternative choices to the full paper three representative choices may be singled out :

Choice I. The Majority Choice consisting of Qs. 1, 2*c*, 2*d*, 3*a*, 3*b*, 4*c*, 5*a*, 5*b*, 6*c*, 6*d*, 7, 8*a*, 8*b*, 9*a*, 9*b*, 10*a* and 10*b* of which the total allotted mark is **100** and the total optimum mark is **89.**

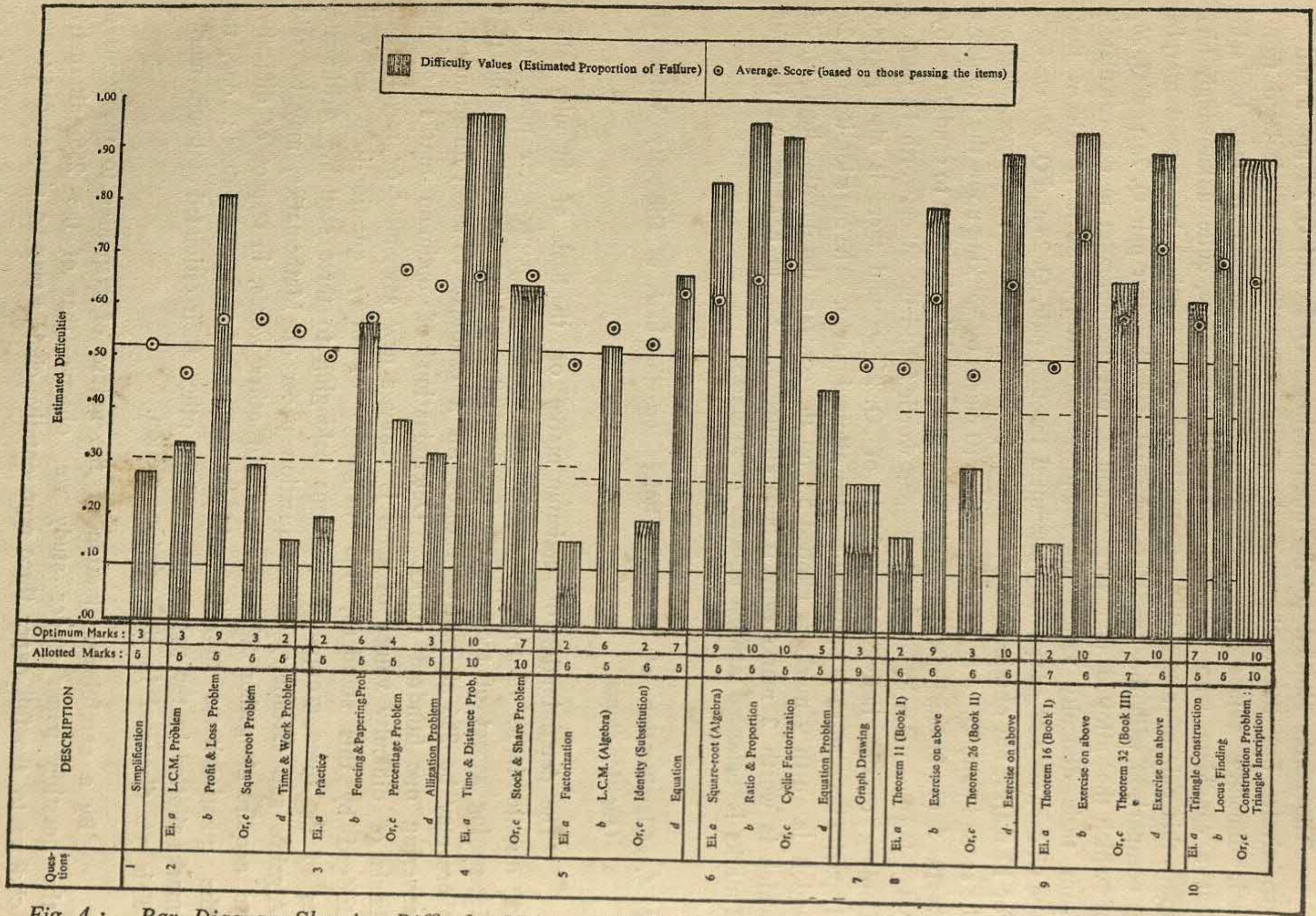

Fig. 4 : Bar Diagram Showing Difficulty Values of Different Question-items on Mathematics (Compulsory) Paper of the School Final Examination, 1952, West Bengal.

Choice II. The Most Difficult Choice consisting of Qs. 1, *2a*, *2b*, *3c*, *3d*, *4a*, *5c*, *5d*, *6a*, *6b*, 7, *8c*, *8d*, *9c*, *9d*, 10*a* and 10*b* of which the total allotted mark is **100** but the total optimum mark is **110.**

Choice III. The Most Easy Choice consisting of Qs. 1, *2c*, *2d*, *3a*, *3b*, *4c*, *5a*, *5b*, *6c*, *6d*, 7, *8a*, *8b*, *9a*, *9b* and 10*c* of which the total allotted mark is **100** but the total optimum mark is **82.**

A note of explanation is perhaps necessary for these three selected choices. The Majority Choice and the Most Easy Choice are identical except in respect of Q. 10. The majority of candidates have chosen Qs. 10*a* and 10*b*, of which the allotted mark is 10 (5 + 5), but the optimum mark is 17 (7 + 10). They have not chosen Q. 10*c*, which as a single item, is much easier, for its allotted mark is 10 and optimum mark is also 1'0. The reason seems to be that in view of the comparatively easy nature of Q. 10*a*, candidates confident of securing at least 5 marks, did not perhaps want to take the risk of 10-marks by attempting the single item, Q. 10*c*. The characteristics of all other 253 (256 - 3) choices would be more or less like any one of the three representative choices considered above.

It is obvious that the optimum marks of all the 256 choices would lie between 82 (the total optimum mark of the Most Easy Choice) and 110 (the total optimum mark of the Most Difficult Choice). In between the two extremes lies the optimum mark of Choice I, which is 89. Hence we may say that simply because of chance choices a candidate not necessarily of higher calibre gets an advantage over or fares equally well as a candidate of superior merit. We feel that a paper-setter should take care to avoid such contingencies so that injustice may not be done to candidates of really good calibre. It is accepted on all hands that a properly framed question paper should contain items of difficulty values of different grades. In the paper under survey we find that frequencies of failures (marks below 30), passes (30—79) and distinction marks (80 and above) are 383 (10.3 per cent), 3174 (85.4 per cent) and 160 (4.3 per cent) respectively. These figures plainly show that the question-paper under survey contains many items of low difficulty values of which the optimum marks are necessarily low. In other words, the determination of optimum marks and the study of question-items under the three selected choices clearly hold out the fact that chance selections have played a vital role in influencing the final results of candidates.

In Fig. 4, p. 52, a Bar-diagram is given to show the difficulty values of all question-items. The centered circles stand for average scores for each item of successful candidates only, that is, of candidates securing thirty or more marks. For the numerical values of these average scores, the Col. 8 of p. 17 (Table 3) may be referred. The horizontal line through the point, 0·103 on

TABLE 8 : *The Question-items falling under the Choice I, Choice II and Choice III, shown with their Allotted Marks, Estimated Difficulty Values (Method VI) and the Optimum Marks.*

Majority Choice (Choice I)					Most Difficult Choice (Choice II)					Most Easy Choice (Choice III)				
Item No.	Short Description of Question-items	Allotted Mark	Diffi-culty Value	Opti-mum Mark	Item No.	Short Description of Question-items	Allotted Mark	Diffi-culty Value	Opti-mum Mark	Item No.	Short Description of Question-items	Allotted Mark	Diffi-culty Value	Opti-mum Mark
	Arithmetic					*Arithmetic*					*Arithmetic*			
1	Simplification	5	.28	3	1	Simplification	5	.28	3	1	Simplification	5	.28	3
2c	Square-root Pr.	5	.30	3	2a	L.C.M. Prob.	5	.33	3	2c	Square-root Pr.	5	.30	3
2d	Time & Work	5	.16	2	2b	Profit & Loss	5	.82	9	2d	Time & Work	5	.16	2
3a	Practice	5	.20	2	3c	Percentage Prob.	5	.39	4	3a	Practice	5	.20	2
3b	Fencing & Pap.	5	.56	6	3d	Alligation Prob.	5	.32	3	3b	Fencing & Pap.	5	.56	6
4c	Stock & Share	10	.64	7	4a	Time & Distan.	10	.98	10	4c	Stock & Share	10	.64	7
Sub-Total		35		23			35		32			35		23
	Algebra					*Algebra*					*Algebra*			
5a	Factorisation	6	.16	2	5c	Identity	6	.20	2	5a	Factorisation	6	.16	2
5b	L. C. M.	5	.54	6	5d	Equation Prob.	5	.68	7	5b	L. C. M.	5	.54	6
6c	Cyclic Factor.	5	.94	10	6a	Square-root	5	.85	9	6c	Cyclic Factor.	5	.94	10
6d	Equation Prob.	5	.46	5	6b	Ratio & Prop.	5	.97	10	6d	Equation Prob.	5	.46	5
7	Graph Drawing	9	.29	3	7	Graph Drawing	9	.29	3	7	Graph Drawing	9	.29	3
Sub-Total		30		26			30		31			30		26
	Geometry					*Geometry*					*Geometry*			
8a	Theo. 11 (Bk. I)	6	.19	2	8c	Th. 26 (Bk. II)	6	.32	3	8a	Theo. 11 (Bk. I)	6	.19	2
8b	Ex. on Above	6	.82	9	8d	Ex. on Above	6	.92	10	8b	Ex. on Above	6	.82	9
9a	Theo. 16 (Bk. I)	7	.17	2	9c	Th. 32 (Bk. III)	7	.67	7	9a	Theo. 16 (Bk. I)	7	.17	2
9b	Ex. on Above	6	.96	10	9d	Ex. on Above	6	.92	10	9b	Ex. on Above	6	.96	10
10a	Triangle Constr.	5	.63	7	10a	Triangle Constr.	5	.63	7					
10b	Locus Finding	5	.96	10	10b	Locus Finding	5	.96	10	10c	Ins. a Triangle	10	.91	10
Sub-Total		35		40			35		47			35		33
Full Question Paper :		100		89			100		110			100		82

the y-axis denotes that there is a figure of 10.3 per cent failure for the sampled candidates. The other horizontal line through 0.517 on the y-axis represents the fact that 51.7 is the average score of successful candidates on the full paper. The three dotted horizontal lines covering the three branches of the paper are meant for comparison of optimum marks of Arithmetic, Algebra and Geometry, based upon the ratio of the total optimum marks of each branch to the total optimum marks of the full paper in the case of question-items included in Choice II, the most difficult one for the candidates. The three sets of question-items covered by the three choices along with their respective allotted and optimum marks are given in Table 8, p. 54.

11.5. The Difficulty Values : Their Usefulness and Limitations :

In order to avoid, as far as possible, the chance factors being called into play, paper-setters should particularly attend to the comparative difficulty values of question-items, which are to form alternative groups in a question paper. The balanced question-items, the types of which have been encountered in the present paper on Mathematics, should always be of at least approximately equal difficulty values. With a view to secure some information which may help the examining authorities (the paper-setters) in their allotment of marks to the question-items proposed to be included in a question-paper, several such studies for each subject should be conducted for a few consecutive years. Pools of question-items of predetermined difficulty values, on different subjects may be collected through a series of such studies and they would prove very useful to both paper-setters and administrators of public examinations.

An important result of the studies on difficulty values of question-items on a subject will be the determination of proper weightages of different branches of a subject. We have shown before that in the light of estimates of difficulty values of questions-items, the proper weightages of Arithmetic, Algebra and Geometry ought to have been 30, 28, and 42 respectively and not the present weightages 35, 30, and 35 given to them by the Board. But in the Technical Appendix II of this Report is included a study based on intercorrelations of scores on the three branches, as well as the correlations of scores on each branch with those of the aggregate. It gives a method by which a set of weights for the three ·branches may be derived for the purpose of obtaining maximum discrimination of candidates. The weights so obtained are found to be more or less in aggreement with those calculated from the optimum marks of the question-items.

The limitations of such studies however must be clearly remembered. Estimates of difficutly values or optimum marks or weightages of different branches of a subject which have already been discussed, depend upon and are calculated from the responses of candidates. These are determined rather through a process of back calculations and certain statistical assumptions, because candidates first responded to the items and then from the data on their responses the difficulty values or the optimum marks were calculated. The reliability of these findings may accordingly be low, unless they are made sufficiently broad based on the data of more than one year's examination results. Several such studies are therefore considered necessary. They will help us, in the first place, to obtain reliable values of these findings ; and secondly, to cover all types of questions in a subject and pave thereby the way for standardisation of question-items in a public examination in the course of a few years.

There is another limitation to these findings of the difficulty values and the optimum marks. All these estimates are liable to change if and when performances of candidates of superior intellectual level are taken into consideration, and that is quite possible when there will be a general uplift of the standard of both teaching and learning.

Though the main aim of a public examination is to rank candidates in order of merit, yet it cannot be denied that one of the aims of public instruction is to raise the standard of education. If circumstances improve as a result of more efficient teaching and of thorough screening of candidates through admission tests and internal examinations, then perhaps from the responses of properly instructed candidates of real merit, it will never be possible to get high difficulty values of question-items in public examinations, unless the question paper includes items which are inordinately difficult in character. In other words, the result will be that under such circumstances low scores and automatically low levels of discrimination as well, will be the things of the past ; naturally the instances of the optimum mark of an item being widely different from its allotted mark will not frequently occur. We envisage an all round improvement of public instruction under which the quality of the sampled population of School Final candidates will be of far better quality than what it is to-day.

The study of difficulty values and discriminating powers of question-items now leads us to consider another more concrete aspect of the question-paper, namely, its suitability and its relation to the Syllabus of School Final Mathematics in West Bengal, on which the paper under survey is based.

PART V

THE PRESCRIBED SYLLABUS AND THE QUESTION PAPER

12. THE QUESTION PAPER IN ITS RELATION WITH THE PRESCRIBED SYLLABUS ON COMPULSORY MATHEMATICS

12.1 Contents of the Question Paper :

We have so far devoted to the study of different aspects of question-items, namely, their discriminating powers and difficulty values, their allotted marks and estimated optimum marks and lastly, the relative weightages of the three branches of School Final Mathematics—Arithmetic, Algebra and Geometry, as they are and as they should be.

The syllabus of the Compulsory Mathematics on which the question paper under survey is based has been reproduced earlier in the second part (pp. 7—11) of this report. We now propose to investigate how the question paper stands in relation to the prescribed syllabus which gives in broad outlines the topics to be done for the examination. The usefulness of such an investigation lies in the fact that the very aim of the examination has the chance of being defeated if the paper-setter in selecting the question-items does not fully respect the limitations of the subject-area imposed by the syllabus. A crossing of the boundary of the syllabus is as unjust as leaving out some portions of the syllabus unrepresented in the question paper. An ideal question paper on a subject, as we know, should be a stratified random sample (topic-wise stratification) of all possible question items on the total area of the subject,

The entire system of public instruction may be looked-upon as a series of closely linked educational activities. The syllabus lays down the contents of the course ; the class-room instruction deals with those contents ; the paper-setting again has got to refer to the contents of the syllabus. But the majority of examiners on a subject of the present day public examinations, while assessing the performances of candidates do not generally get the chance of judging how far the question paper is representative of the contents of the syllabus, and their assessments as such are likely to be vitiated by factors beyond their control.

Keeping this situation in view, the study is now directed towards investigating :

(*i*) How far the different subject areas of the syllabus are represented in the present question paper ; that is, how far can the question-items on a particular branch be considered representing the branch itself in all aspects, and what are the topics in each branch on which question-items should have been set but have not been set ;

(*ii*) To what topics of the present syllabus the candidates are non-responsive, as revealed by their avoidance or poor-performances ;

(*iii*) How far the question-items and the candidates' performances thereon can be considered to provide a reliable measurement of mathematical ability, which as we know, is the main objective of the examination ;

(*iv*) What changes might be suggested under the present syllabus in the matter of setting questions, in order to have desirable weightages for the three branches of School Final Mathematics : namely, Arithmetic, Algebra and Geometry ;

and (*v*) What should be the syllabus of School Final Mathematics considering the need for turning out the College capables for the present day scientific and technological education in the Universities.

12.2 The Question Paper and the Subject Area :

Let us first investigate whether the different areas of the subject under the syllabus have found reasonable representation in the question paper. A comparison of the question-paper and the syllabus shows that there are some important topics under the syllabus which are not included in the question paper, and that there are in the paper certain question-items on topics which are not explicitly mentioned in the syllabus.

In Arithmetic, Proportion, Simple Interest, and Reductions are the three main topics in the syllabus, but not a single question on any of these topics is included in the question paper.

In Algebra, the case appears to be somewhat better. Here we find that the question-items of this branch fairly cover almost all the topics of the syllabus. Though the topic of Identity (Substitution) on which a question has been set does not find mention in the syllabus, yet the setting of this question-item may perhaps be justified because constructively Identity can be regarded as a problem requiring for its solution a thorough knowledge of the fundamental topics of Algebra included in the syllabus.

In Geometry, not a single problem or theorem on the Concurrence of Straight Lines in a triangle is included in the question paper, although the syllabus includes four theorems on concurrences that are to be studied by the candidates. In the second place, the syllabus includes a very comprehensive chapter on Circles including both theorems and riders thereon. But it is worth noting that only a single theorem on Circles (Book III) with a rider on the same has been set and that again as an alternative item to an elementary problem on Triangles (Book-I), which students generally read in Classes VII and VIII of Secondary Schools. Thus a proposition of Book III on Circles has been equated, by the paper-setter, to one of Book I on Triangles. The effects of such unbalanced alternatives are reflected in the observed frequencies of attempts on these two items. Out of a total of 3717 candidates as many as 3428 attempted Q. *9a* (proposition on Triangle of Book I) whereas only 96 of the candidates responded to Q.*9c* (a proposition on Circles : Book III).

Lastly, a problem on Locus finding which carries five marks is set not as a compulsory item but is tagged to a very easy item of 5 marks on Construction of a Triangle. To make the matter worse, there stands against these two tagged items of 5 marks each, an alternative single question-item of 10 marks on the Inscription of a Triangle, a topic not explicitly mentioned in the syllabus. Such tagging and balancing of alternatives have resulted in very poor responses both to the problem on Locus finding as well as to that on Inscription of a Triangle. The observed frequencies of responses to these items, namely, 1551 for Q.10*a*, 255 for Q.10*b* and 228 for Q.10*c* (see Table 2, P-14,) explain the situation. The Q.10*a*, being comparatively an easy item, attracted as many as 1551 candidates, but this 'attraction of an easy item' was no longer there in the case of Q.10*b*, the second part of this question—a problem on Locus finding, which appears to be so difficult that not more than 255 of the candidates could attempt it. Evidently, a majority of 1551 candidates attempting Q. 10*a*, were unable to approach the other part Q.10*b* of the question, and it is not unlikely that the observed 255 attempts on the latter includes some cases not belonging to the former group of 1551 candidates. To both of these stands the big single alternative of 10 marks on Inscription of a Triangle, (Q.10*c*) on which only 137 out of 228 attempts to the item have been successful. All these show that the paper-setter did not fully appreciate the importance of Locus finding, which forms a separate section in the syllabus. Such tagging of question items is hardly justified in this case.

This is not all. In the syllabus we find that geometrical theorems corresponding to algebraical identities occupy a prominent place. But in the present question paper there is not a single item on these topics of the subject.

Turning now to see if there were any question-items in the paper on topics which did not find explicit mention in the syllabus we find a few cases which may not escape one's attention. The topics in Arithmetic, namely, problems on L. C. M., Profit and Loss, Time and Work, Papering and Fencing, Percentages, Alligation, and Time and Distance are not explicitly mentioned in the syllabus. But comparison of question papers of several years shows that setting of questions on these topics has been customary in the past Matriculation Examinations. Perhaps, this justifies the incorporation of question-items Qs. *2a*, *2b*, *2d*, *3c*, *3d* and *4a* on such topics in the present paper, although they may appear to be out of syllabus from the view point of its present version. It may, of course, be said that the question-items referred to here are really on applications of the "four fundamental rules of Arithmetic," which finds mention in the syllabus. But problems on 'Alligation' or 'Fencing and Papering' and the like require distinct methods of approach and as such candidates must have plenty of practice in handling such problems and as such these topics should have been explicitly stated in the syllabus.

In Algebra, the syllabus is rather cryptic and brief. Questions set in Algebra are on topics which are mentioned in the syllabus, except perhaps the item on 'Identity'. It may be noted that the number of responses on Identity is only 782 out of 3717 candidates. It is well-known that Identities, as a type of algebraical problems are treated in separate chapters in all standard text books on High School Algebra and it is really unjust to set questions on such a topic on the ground that identities can be solved by applying the methods of factorisation. In our opinion the topic on Identity should have also been explicitly stated in the syllabus.

In Geometry, there is only one question-item, Q. 10*c*, on the Inscription of a Triangle, a topic which is not explicitly mentioned in the syllabus and there have been very poor responses on the item.

We feel that the syllabus of any subject should be more descriptive and explicit in character and details of topics of different nature should be stated in the syllabus, as far as possible.

12.3 The Question Paper and the Measurement of Mathematical Ability :

We may now consider how a question paper and candidates' performances thereon influence the purpose of examinations, namely, measurement of abilities in different subjects. The performances on a full paper on Mathematics may be said to measure mathematical ability only when the question paper is fully representative of the area of the syllabus as a whole. In the present question-paper, all aspects of the syllabus do not appear to have received due consideration of the paper setter. It is worth noting that, while some important topics done in top classes have been left out, a number of topics done in lower classes, namely Classes VII and VIII have been included in the question-paper and the latter have contributed much to raise the average score on the paper. A lack of satisfactory correspondence between the syllabus and the question paper, as observed here, is likely to tell on the reliability of the measurement of ability in mathematics based on the performances of the candidates in this Question Paper under survey.

12.4 The Optimum Weights of the Three Branches of Mathematics :

Next we consider the present syllabus from the view point of 'optimum weights' for the three branches of Mathematics. In the previous section we have shown that the proper weightages of Arithmetic, Algebra and Geometry should have been 30, 28 and 42 in place of their present weights 35, 30 and 35 respectively. These optimum weights have been calculated from the 'optimum marks' of question items of all the three branches of Mathematics. We are thus led to the conclusion that the weight of Arithmetic should be less and that of Geometry, more than what they are at present, the weight of Algebra being almost at par with its present value. Hence we may suggest that in terms of round figures, the weightages should be 30, 30 and 40 for Arithmetic, Algebra and Geometry and question-items should be distributed accordingly, in the present form of syllabus and curriculum of the subject.

12.5 The Principle of Paper-setting in School Final Mathematics :

As regards the setting of question-items in general, the basic principle should be that a good portion of a question paper should cover those topics which are done in the top Classes of Schools. On fundamental concepts of the subject generally introduced in lower forms of schools, the question-items, if set at all, should be in the nature of concrete practical problems. The study enables us to make the following specific suggestions in regard to setting of question-items in Mathematics at the School Final stage.

In Arithmetic, the questions on Simplification, Practice, and the Elementary Problems of Time and Work, Fencing and Papering etc., should not be set at all, because the candidates must have had many previous internal examinations (if not at least one public examination) which tested their knowledge on these topics.

In Algebra, Graphs and Problems on Simple and Simultaneous Equations, should be made compulsory items and not tagged as alternatives to questions on other topics.

In Geometry, questions on elementary theorems of Book I (Straight lines and Rectilinear figures) should be dropped altogether, for, as in the case of elementary Arithmetic, the students had many occassions of being examined on this part of Geometry in the lower forms of their respective schools. Questions should be set on concurrence of straight lines in a triangle, theorems and problems regarding circles, and other harder topics of the subject. Intelligent riders on Book Propositions should gradually be given preferences in order to discourage memory work in Geometry.

If such changes are brought about, both teachers and students in class-rooms will lay emphasis on those important areas of the subject which have hitherto been neglected.

We feel that paper-setting should receive more careful consideration of the administrators of public examinations. For it is this work alone which, if properly done, can tone up the whole educational system. It is perhaps worthwhile to remember that one of the important pre-requisites, if not the most important, for making a satisfactory question paper on a subject of a public examination is a detailed and descriptive form of syllabus which, we are afraid, are not always available in our country.

13. THE PRINCIPLES OF THE SYLLABUS OF SCHOOL FINAL MATHEMATICS

13.1 Construction of the Syllabus—The Objectives :

The syllabus of any subject at any stage of education particularly at the secondary stage should be framed with two objects in view. First, the subject areas should be so chosen that a knowledge of the topics included in the area should help a student in continuing further collegiate and university education in that subject. Of course this object is rather academic in nature. Secondly, in the present set-up, Secondary Education is considered by the authorities as a self contained system and the students are expected to learn certain subjects, in which their knowledge may help them in continuing their training in further Technical or Commercial Courses. For example, a student passing the School Final Exmination may now go in for training as an apprentice in Civil, Mechanical or Electrical Engineering, Draughtsmanship, Surveying and the like. To satisfy the two purposes mentioned above, the present syllabus of School Final Mathematics which has hitherto been followed needs a thorough revision and re-orientation.* Experience of teachers in technical schools and colleges has often shown that even students who had secured good marks in mathematics in their School Final and Intermediate examinations find it difficult to tackle problems which involve practical applications of algebraical and geometrical principles they had theoretically learnt at the secondary stage.

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* The Secondary Education Commission (1951) has attended to some of these points in formulating the Syllabii for Higher Secondary Courses.

There is another factor which requires careful consideration. It is admitted on all hands that the present system of education involves a large amount of wastage of money, time and education. Though the main cause of such wastage lies in discontinuance of education at any time before the School Final stage is reached, yet it must be said that repetition of the same syllabus is a factor which involves wastage of time. In the syllabus of Mathematics, we have noted, there are topics which are usually done in lower forms and on which questions are set to measure mathematical ability of school final candidates. The result is that really important topics of advanced courses which are done in top classes of high schools have to be sacrificed by the paper-setter in consideration of a single three-hour paper for the whole subject. We suggest that this drawback is not a necessary evil and it can be easily rectified if the paper on mathematics only includes those topics of all the three branches which are done in Classes IX and X only. Lest such innovation in paper-setting should disturb the candidates in the examination hall, at least one year's notice previous to the examination may be given to this effect. Then we shall not perhaps put the candidates at any disadvantage.

There is another aspect of the question paper connected with the change of the School Final syllabus in the present set-up. The report of the Secondary Education Commission, 1951 strongly recommends that the structure of the Secondary Education in all states of India should be similar as far as possible. We also feel that when All India Council for Secondary Education is engaged in giving effect to the recommendations of the Commission the syllabus of any subject, not of Mathematics alone, should follow a common pattern in all the states of India. Considering all the above mentioned factors we feel that if the syllabus of Mathematics has to undergo changes—the changes should be aimed at giving the syllabus a strong practical bias. By the term 'practical bias' we mean a tendency to lay more emphasis on the practical application of abstract fundamental principles of Mathematics.

Perhaps it will not be out of place to mention here that in U. S. A. a Commission was set-up to investigate into the desirability of changes to be introduced in the syllabus of Secondary School Mathematics. Teachers, Administrators, and also authorities of the Universities and various Technical Institutions were consulted in this connection. Among other things, they agreed that the traditional course of Mathematics, which lays emphasis on fundamental principles only, should be changed and 'New Mathematics' should be introduced in all its branches, namely, Algebra, Geometry and

Trigonometry, etc. By 'new mathematics' they mean the applied aspect of mathematics which the students have got to learn in the course of their technical and collegiate education.

Coming to the present syllabus of School Final Mathematics in West Bengal, we find that a large portion of the syllabus is devoted to fundamental principles. The result is that students are confronted with great difficulties when they go in for technical and commercial education. One example may be given ; calculation of squares and extraction of square roots of abstract numbers are taught in arithmetic ; in geometry, they are also taught theorems and problems on areas of triangles and quadrilaterals. In Surveying and Mensuration the very same principles are applied under various circumstances. Because students do not undergo sufficient drilling in these problems they invariably find it difficult to tackle problems of mensuration in which determination of square and cubic measures is involved. Another example may be given from geometry. It is well-known that from the basic theorem stating 'the sum of the three angles of a triangle is equal to two right angles' many properties of regular rectilineal figures may be found out. In fact, in standard books of School Geometry which are taught in West Bengal, these things are given. It is the question of emphasis which makes all the difference. Even if a student cannot successfully prove the elementary theorems such as Q. 9*a*, Book I, of the Question Paper under survey, but knows thoroughly well the application of the truth of the proposition, it would not at all be difficult for him to find out the properties of a regular polygon.

13.2 Concluding Remarks :

The above comments made on the Syllabus of School Final Mathematics refer to that of class X High Schools which send up candidates for the School Final Examination. They may not apply to the syllabus of Higher Secondary Schools (Class XI Schools) which are being founded all over India in pursuance of the recommendations of the 1951-Commission. The first public examination of candidates from Higher Secondary schools is going to be held in the year 1960. Performances of candidates who are being taught under the 'new system' may then be analysed in the light of the 'new syllabus' of mathematics. But as things now stand, the vast majority of secondary schools of West Bengal are still continuing as class X schools and follow the syllabus which has been the subject of our study. We feel that this clarification is necessary because of the dual system of secondary education, the secondary and the higher secondary, which is now obtaining in the State to-day.

PART VI

RELIABILITY, VALIDITY AND STANDARDISATION OF AN ACHIEVEMENT TEST ON MATHEMATICS

14. RELIABILITY AND VALIDITY OF PUBLIC EXAMINATIONS

14.1. The Concept of Reliability and Validity of a Test :

The functions of a measuring instrument of a laboratory can very well be compared with those of a set of achievement test-items. For measuring a physical characteristic of a thing or substance in a scientific experiment, some suitable instrument is used. When a satisfactory instrument is not available, one such is of course devised for the purpose. Similarly a suitable test or a battery of tests, when made available, is used for measuring the abilities, attainments or general proficiencies of a group of students sitting for an internal or public examination in any one or all the several subjects of the curriculum* ; and when not, one or more is devised for the purpose.

The reliability of a test or a measuring instrument refers to the degree of *consistency* with which it measures what it intends to measure, admitting if at all, only an insignificant margin of error. The margin of error is defined here, as the difference of a particular reading and the mean of several readings by the same instrument under identical conditions.

The validity of a test on the other hand, refers to the degree of *accuracy* with which it measures what it intends to measure. Evidently, a comparison of measures obtained by a given test or instrument with some true or precise measure by the use of a standard (criterion) test or instrument is always necessary, in order to estimate the validity of the test or instrument in question.

In the case of a measuring instrument, the two concepts may be illustrated thus : A certain barometer may be quite dependable (consistent) only when it gives readings which are almost always (failing only in one to five per cent cases, say), either coincident with or fall in close proximity of the mean value of the readings on the atmospheric pressure at a place taken under identical circumstances. Such a dependable instrument may be said to possess a high degree of reliability. But if we are to bring in the question of validity of the aforesaid instrument, we have to compare its readings with those of a standard (criterion) barometer whose readings are known to show always the *true* measure of the atmospheric pressure.

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* An examination is a relatively free and extended written response to a problematic situation or situations (question or questions), which intentionally or unintentionally reveals information regarding the structure, dynamics and functioning of the students' mental life as it has been modified by a particular set of learning experiences—Sims, V. M. (1948). "The Essay Examination is a Projective Technique." Edu. Psyc. Vol. 8.

Now, as in the case of an instrument, the reliability of a test will refer to the degree of consistency with which it measures what it purports to measure on different occasions of the applications of the test. The determination of reliability of an instrument does not appear to be difficult, since taking of more than one reading under identical circumstances of an object by the same instrument is quite possible if sufficient care is taken. But when we are confronted with the problem of finding the reliability of a psychological or an achievement test used for the measurement of abilities or attainments in a particular subject of an examination or for that of the general proficiency of the candidates by administering a battery of tests, the problem appears to be extremely complicated. It is impossible to re-administer a test, whose reliability is to be investigated, on the same group of candidates under identical circumstances and obtain unbiased scores for our purpose. In fact, unlike a parallel reading of an object which hardly undergoes change, by a dependable instrument, the scores on a re-administered test would lack practical utility. To encounter such situations one of the suggested methods worth considering is to construct tests which may be reasonably taken as parallel to the one whose reliability is sought for. When the results of administration of only one form of the test is available, a different suggestion worth noting is to build half-tests or fractiles out of the whole test and find suitable formula for estimation of reliability of the test from a knowledge of the inter-correlations (internal consistencies) of the split-halves or the split-fractions of the original whole test.

If we are to investigate the validity of the test again, it is essential to have a criterion test for the situation. In the example of the barometer, as we have already noted, the establishment of validity depended on favourable comparison of its readings with those provided by a standard (criterion) instrument. The situation is, however, much more complex in the case of tests for measurement of psychological characteristics like human abilities or achievements than in the case of an instrument.

It is not very difficult to find an instrument which is capable to measure an object correctly when it is a question of measuring the validity of a similar instrument at hand. But it is a problem to find a criterion test when we are to measure the validity of a public examination, say, the School Final Examination of a particular year. It is really difficult to find a *second test* in this situation, the scores on which can be assumed to be a set of precise parallel measures of individual attainments of the examinees, for necessary comparison with their corresponding observed scores in the public examination, the validity of which is to be determined.

In view of such complexities, it may be considered worthwhile to analyse and investigate what the criterion should denote and connote in cases of different types of public examinations. A reasonably valid test item or a whole test on a subject should measure the proficiency in the subject and at the same time must be suitable from the viewpoint of the syllabus for the examination. Any question-item which is set on topics not included in the syllabus prescribed for a group of candidates in a particular test can never be valid. The limitation of the syllabus is thus a factor which goes to influence the validity of a test-item.

The language of the test-item again, if not clear and unambiguous may seriously tell on its validity. Instances are not infrequent when a question-item, even when it is within the prescribed syllabus, shows poor measure of validity, possibly due to its being couched in a language beyond comprehension of the class of candidates for whom the question-item was meant. The present system of teaching a subject in one language, but setting of questions in another creates confusion of candidates ; so the media of instruction, of paper-setting, and of examination (answering) must be one and the same.

Again, if an item is such that a candidate may score good marks by memorising the possible answers, then the validity of the item is seriously affected ; because response to the item does not go to measure the ability of the candidate in the subject concerned. In other words, without understanding the question at all, a candidate may get full credit for his performance. For instance, in the question paper under survey some elementary theorems from standard books on Geometry have been set as question-items to measure the proficiency of candidates in the subject. Such standard book-theorems, a candidate by sheer memory, can reproduce verbatim and score full marks. It is of course admitted that on some question-items over essential topics of a subject, candidates may score full marks by memorising the possible answers. Instances may be quoted on question-items like, "State Newton Laws of Motion" in Mechanics or "State Kepler Laws on Planetary Motion" in Astronomy. In such cases it is very difficult to judge whether the candidates who score full marks, memorise the answers with full understanding or not. In general, however, the memory, a psychological factor, if found considerably involved in the scores on a test-item, it becomes very difficult to determine the correct measure of its validity.

14.2. On Measuring the Reliability and Validity of an Achievement Test :

In the last section we explained the concepts of reliability and validity and discussed the points of contrast between them. The determination of reliability and validity of achievement tests poses problems which are much more complex than those of psychological tests.

A valid test as we know correctly predicts the ability of a candidate. Ranking of candidates is seemed to be most perfect if it is based on the results of a valid test. But one of the preconditions of the measurement of validity of any test is the selection and the availability of a suitable criterion. In the case of an achievement test like a public examination involving a large number of subjects in the curriculum and a large population of candidates, it is very difficult to find a criterion test, the scores on which may be compared with the results of the examination concerned.

We can however try with the results of an internal test examination which is held to select candidates to be sent up for a public examination. But the difficulty is that the internal examinations of different institutions can hardly be found to possess that much of one-ness (uniformity) which may enable us to compare their scores with those of a public examination to obtain a satisfactory estimation of the validity coefficient.

Uniformity in the internal test examinations of different schools may be expected on the ground that in all of them the same curriculum and the same syllabus and apparently the same types of instructions are followed. But the fact is that the individual differences of schools come into play to disturb the equality of their examinations.

In consideration of these difficulties, some hold the view that the determination of validity of a public examination should not be pushed too far. They think that it is better to go on with improving the reliability of a large scale public examination because in the long run, a high degree of reliability automatically secures a reasonably good validity of an achievement test or examination.*

For the estimation of reliability of an achievement test there are three standard methods : (*i*) Method of Parallel Tests. (*ii*) Test-Retest Method and (*iii*) Split-half or Split-multiple Method. Of these,

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*"Some are of opinion that when a criterion is not available at hand for a satisfactory measurement of the validity of an achievement test, it is better to proceed with an attempt to increase the reliability of the test. The higher the reliability of an achievement test, the higher must be its validity."—*H. Gulliksen, (1948).*

the first two are rather impracticable, because they involve a large number of personnel as well as considerable expenses. Moreover, it is not possible to assemble all the candidates once again and compel them to sit for a second examination. Besides, one of the weak features of the test-retest method is that the operation of memory may come into play and influence the scores in the second examination. To overcome this difficulty, the general procedure is to hold the two tests at a fairly long interval. This again creates a difficulty of administration of the test. Accordingly, the split-half method of obtaining the reliability of a test is most suitable in the case of a public examination.

The split-half method requires no parallel tests nor a retest with the question paper. We have to construct two similar sub-tests from the test at hand by dividing the question-items of the paper into two equivalent and similar halves. The division however is made on the following principles ; (*i*) the number of questions in the two halves and their face values should be equal as far as possible, (*ii*) the mean scores and standard deviations of scores in respect of the two halves should be equal as far as possible, (*iii*) the nature of the question-items in the one half should be similar to that of question-items of the other half. It is not difficult to extend this concept, if and when required, of constructing the half-tests from a complete one in a situation where the test may yield to a convenient partitioning into more than two equal components possessing as usual equal means, equal standard deviations and equal inter-correlations. Sometimes improved estimates of reliability may be obtained by split-multiples instead of split-halves of a test.

15. THE RELIABILITY OF THE QUESTION PAPER UNDER SURVEY

15.1. Reliability of a Question-item :

Generally, reliability of a question paper on any subject is the concern of the examination authorities. But the determination of the reliability of each and every question-item is also interesting, because in a question paper like that of Mathematics, there are items which are widely different in nature and they belong to three separate branches of the same subject. So it is worth while to determine the reliabiliy of the individual question-items.

The data for estimating the discriminating power of individual items (see Part III—pp. 31-42) and the bivariate tables for frequencies of scores on an item and the total score on the paper (see Appendix Tables) will be required for estimating the reliability of individual items of the paper. If however, the total score on the paper is looked upon as criterion score, the item-total correlation coefficient can naturally be regarded as an estimate of the reliability or even the validity of the question-item concerned.

We have not calculated the product-moment correlation, because, in the first place, it is time-consuming and secondly, the frequency distributions of scores on the items are far from normal in most cases. Instead, we have computed biserial correlation coefficient for all the items. Several other measures of correlation, like tetrachoric correlation, Yule's coefficients of association and colligation, and Sheppard's coefficient have been obtained for a comparative study. The results are shown later in Table 10 in Section 16, which we have devoted to the study on the measurement of validity of the question-items.

15.2. The Reliability of the Question Paper :

For the present, the reliability of the question paper as a whole, that is, the consistency with which it measures the ability of the candidates in the subject, is our chief concern. To measure the reliability of this Mathematics question paper, we have adopted the Split-half Method (Kuder-Richardson, 1939), being a convenient and practicable method in the situation.

By this method the whole question paper is split up into two halves, each half containing question-items of which the mean and standard deviation of scores are almost equal to those of the items of the other half. The application of well-known statistical methods of testing the equality of means, variances, and correlations etc., of two or more samples helped determining a satisfactory partitioning in the situation.

If the two equivalent halves of the question paper are thus constructed, the correlation coefficient between the scores on them would give an estimate of the reliability of each half of the question paper, and we denote this by $r_{\frac{1}{2}\frac{1}{2}}$. To obtain the reliability of the whole question paper which is denoted by r_{11}, the application is made of the Spearman-Brown formula for double length, namely,

$$r_{11} = 2r_{\frac{1}{2}\frac{1}{2}} / (1 + r_{\frac{1}{2}\frac{1}{2}}).$$

If we denote by the symbol X, the scores on the first half, and by Y, those on the second half, and assume the equality of means and variances of the two half-tests, and then estimate the mean values of both the halves by the average of the arithmetic means of X-scores and Y-scores, and similarly in the case of variances, by the average of the variances of the scores on the two half-tests, the above Spearman-Brown formula for the reliability of the full paper is obtained in the form,

$$r_{11} = \{4(\Sigma X_i Y_i) - (\Sigma T_i)\bar{T}\} / \{\Sigma T_i^2 - (\Sigma T_i)\,\bar{T}\}$$

where, if N denotes the size of the sample of candidates, $T_i = X_i + Y_i$ and $\bar{T} = \Sigma T_i / N$, the symbol Σ denoting the sum for all the N candidates.

The measurement of reliability coefficient by the split-half method for our sample of 3717 candidates appears to be formidable. We therefore took up a study over a conveniently small sub-sample of 81 candidates only. With the same group of students the validity coefficient of the paper has been estimated by taking their scores on Mathematics (Compulsory) paper of their Test Examinations in Schools, (see Table 9, p. 72).

15.3. Estimation of Reliability by the Split-half Method :

Coming now to the problem of dividing the whole test into two approximately equal halves, we find in the present paper that a set of ten question-items suitably selected from the three branches, *viz.*, Arithmetic, Algebra and Geometry may lead to a sub-test carrying just 50 marks. The items for inclusion in the first sub-test are Qs. 1. 2*c*, 2*d*, 3*a*, 3*b*, 5*b*, 6*c*, 6*d*, 10*a* and 10*b*, each carrying five marks. These ten items of total marks 50 are matched against the rest of the test which however, owing to the peculiarly alternative character of the question-item structure of the whole paper is not the same for each of eighty-one students of the sample. But the fact remains that with this particular half of the full paper the marks of the other half consisting of the question-items, *viz.*, Qs. 4*a* or 4*c*, 5*a*, 7, 8*a* and 8*b*, or 8*c* and 8*d*, 9*a* and 9*b* or 9*c* and 9*d* are found to correspond in a very satisfactory way to the marks of the first half of the question paper referred to above.

The calculation shows that the mean and standard deviation of scores for each half are nearly equal. This satisfies a condition of split-half test. The marks of an individual student in the first half with his scores in the second half as well as the full paper are shown in Table 9 of Section 16, along with the totals secured in the full Compulsory Mathematics paper in their test examinations, which we shall use for the estimation of the validity coefficient. The marks of the second half have been obtained by subtracting those of the first half from the total scores on the paper.

Now by the split-half formula, referred to above, the Reliability Coefficient of the full question paper works out to be $r_{11} = 0.6343$, that is approximately, $r_{11} = 0.63$, only.

It should be noted however that for an achievement examination, especially one on Mathematics, a considerably higher value of the reliability coefficient one should expect than what the present paper has shown.

TABLE 9 : *Showing the Data used for Estimating the Reliability and the Validity of Mathematics (Compulsory) Question Paper in the School Final Examination, West Bengal, 1952.*

Serial No.	Scores in the First half	Scores in the Second half	Total scores in the Board Exam.	Total scores in the Test Exam.	Serial No.	Scores in the First half	Scores in the Second half	Total scores in the Board Exam.	Total scores in the Test Exam.
(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)
1	23	19	42	32	41	39	25	64	44
2	40	41	81	62	42	30	33	63	51
3	20	35	55	56	43	30	33	63	70
4	25	28	53	36	44	40	28	68	48
5	25	28	53	53	45	40	37	77	61
6	41	36	77	42	46	15	25	40	30
7	25	23	48	40	47	24	34	58	55
8	35	32	67	52	48	31	23	54	44
9	35	38	73	35	49	30	38	68	34
10	36	43	79	64	50	29	24	53	63
11	30	24	54	36	51	40	48	88	72
12	35	44	79	63	52	40	36	76	79
13	45	34	79	64	53	40	32	72	43
14	30	27	57	47	54	37	33	70	50
15	35	37	72	75	55	30	30	60	50
16	38	41	79	40	56	25	26	51	25
17	33	34	67	39	57	15	9	24	15
18	27	38	65	50	58	15	19	34	32
19	33	37	70	30	59	27	16	43	33
20	27	38	65	43	60	25	49	74	48
21	20	23	43	30	61	33	38	71	46
22	26	25	51	33	62	38	43	81	35
23	13	19	32	39	63	25	16	41	30
24	23	39	62	31	64	30	36	66	35
25	35	28	63	54	65	33	26	59	55
26	33	47	80	82	66	35	28	63	48
27	34	32	66	59	67	24	41	65	41
28	25	27	52	32	68	42	28	70	32
29	35	26	61	70	69	30	37	67	31
30	19	28	47	26	70	35	26	61	47
31	25	15	40	37	71	30	14	44	30
32	40	37	77	66	72	39	33	72	64
33	25	18	43	33	73	40	33	73	73
34	20	28	48	30	74	28	14	42	41
35	33	39	72	42	75	40	36	76	38
36	35	27	62	25	76	34	26	60	53
37	35	34	69	54	77	44	29	73	61
38	30	38	68	62	78	21	24	45	35
39	38	30	68	60	79	40	39	79	73
40	23	34	57	34	80	29	34	63	41
					81	42	49	91	89

16. THE VALIDITY OF THE QUESTION PAPER UNDER SURVEY

16.1. On the Validity of the Question-Items.

In the light of the different aspects of the validity of a test already considered in Sections 14.1 and 14.2, we may proceed to investigate how far the question paper under survey may be said to give valid measures of mathematical ability of the candidates. As in the case of reliability, the validity of the question paper is considered here from the viewpoint of the individual question-items as well as from that of the question paper as a whole.

In Arithmetic, the Q. 1 on simplification really belongs to the syllabus of classes VI and VII of a secondary school. This fact alone vitiates the validity of the question-item for the School Final stage, because here the examination intends to measure mathematical ability of candidates of a higher standard. As a question-item beyond the syllabus can not be said to be valid even if it measures the ability of candidates in a subject, so also it may be said that an item below the standard of the syllabus for the examination concerned loses its validity to a great extent. Judged by this, the question-item on simplification (Q. 1) may not be considered as valid. The question-items, Q. 2*a*, Q. 2*b*, Q. 2*c* and Q. 2*d* are on problems involving L. C. M., profit and loss, square root, and time and work respectively. These items appear to satisfy the formulated conditions of a valid question-item (Section 14.1). The question-item Q. 3*a* on practice has the same story to tell as the Q. 1 on simplification. Here also the topic belongs to a lower standard and it loses much of its usefulness as a measure of the mathematical ability of School Final candidates. The question-items Q. 3*b*, Q. 3*c*, Q. 3*d*, Q. 4*a* and Q. 4*c* are on problems involving measurement of areas, percentages, ratio and proportion, time and distance, and stock and share. These items appear to be suitable for candidates of School Final standard as they satisfy to some extent the conditions of valid test items referred to above.

In Algebra Q. 5*a* and Q. 5*b* are on factorisation and L. C. M., involving principles of algebraical operations with which the students become familiar in classes VII and VIII of schools. As only some mechanical ability of candidates may at best be measured by such question-items, they may not be considered to have satisfied the conditions of validity under the situation. The question-items Q. 5*c*, Q. 5*d*, Q. 6*a*, Q. 6*b* and Q. 6*c* are on topics of some abstract algebraical operations, such as identity, equations, square root, ratio and proportion, and cyclic factorisation. These are, however, based on courses which are covered in top classes of secondary schools under the present syllabus. The question-items Q. 6*d*, a problem on simple equation and Q. 7, on drawing of graphs are the two items which are of elementary nature. These question-items might have been valid for measuring the ability of a student of class IX or below. More intelligent questions could have been set on these topics to test the mathematical ability of School Final candidates.

In Geometry, we have already pointed out in the previous section that questions on theorems given in standard books on geometry, framed without introducing any variation whatsoever are at best good instruments of measuring candidates' memory rather than their comprehension of geometrical principles. It is well-known that whenever memory helps correct responses to a question-item the validity of the item is bound to be vitiated. Judged by this standard, the question-items Q. 8*a*, Q. 8*c*, Q. 9*a*, and Q. 9*c* cannot be said to satisfy the conditions of validity. The question-item Q. 10*c* on the inscription of a triangle, a topic which is not expressly mentioned in the syllabus, is of doubtful validity on this account. The other question-items on Geometry belong to areas which appear to have been adequately described in the outlines of the syllabus. They are neither below nor beyond the standard of School Final examination.

From the above observations on the validity of the constituent question-items of the paper, it is found that out of thirty-one question-items as many as nine items (two in Arithmetic, two in Algebra and five in Geometry) are of doubtful validity. Earlier in this report we pointed out that these defective question-items are really the loopholes through which many candidates having little mathematical ability come out successful and thus the very aim of the examination is defeated.

Neither the validity of the individual question-items, nor the validity of the question paper as a whole can be properly considered without reference to a criterion, which in plain language means a standardized set of questions of unassailable validity. Unfortunately, no such criterion* is available. However, as a workable criterion under the circumstances, for testing the validity of a question-item, we propose to take the aggregate score on the subject to serve the purpose, because the aggregate score is taken as the observed index of achievement in a subject and on it depends the ranking of candidates in order of merit in the School Final examination.

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*'One of the most difficult of all aspects of the validity problem is that of obtaining adequate criteria of what we are measuring. The factor-analysis approach has a fairly good solution when it is primary traits or abilities that we wish to measure. If two or more tests or items are combined to predict the factor, the validity coefficient is the multiple correlation between the tests and the factor. But practical criteria are most in demand and are most difficult to obtain and to measure adequately. An example of this is the criterion of scholastic achievement.'—Guilford, J. P., *Fundamental Statistics in Psychology and Education*—McGraw Hill., U. S. A. (1950), P. 514.

16.2. The Measurement of Validity of a Question-item :

The validity of a question-item is going to be determined here by the correlation between the score on an individual item and the aggregate score on the full paper. The reason is, we have taken it for granted that the aggregate score is the observed index of the mathematical ability of candidates. Disparity between the two sets of scores, one on the item and the other on the full paper, may arise if the question-items are set, either above or below the level of the examination. In such cases, the result is that the items do not measure what they seek to measure. In concrete terms it may be said that if a particular item is either beyond the syllabus or ambiguous in its expression, even good students naturally have low scores on that item. But the aggregate score of really good candidates may not be very low on this account. On the contrary, almost all candidates may score full marks on an easy item which is below the standard, but all of them are not likely to score high marks in the aggregate.

In Table 10 below, measures of correlation between scores on thirty-one question-items and the aggregate score on the full paper have been calculated by five different methods which are shown as column headings. Each of these five series of thirty-one figures may be said to represent measures of both reliability and validity of the items in question. The reason is that the aggregate score, if taken as a criterion, the coefficient of correlation is a measure of validity ; on the other hand, if the aggregate score is looked upon as the score on a test parallel with the item, the measure of correlation between the two may be taken as the measure of reliability of the item concerned.

16.3. On the Validity of the Question Paper :

The validity of a test is determined by comparing the achievements in the given test with a highly precise standard test. Since standard tests, *i. e.* criteria* are rarely available in cases of achievement tests, the validity coefficients in these cases can never be estimated as precisely as that of a barometer. Statistical techniques have been devised in order to estimate the validity coefficients of psychological tests. One of the methods which is widely applied in the field, consists in finding the product-moment correlation between the test and some independent criterion. In the present situation, the above method will require to determine the correlation-coefficient between the marks secured by candidates in the question-paper under survey and the marks secured by them in some standard question paper (criterion test), which can measure the same kind of mathematical ability of the candidates.

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* See *ante* P. 74., footnote.

TABLE 10 : *Estimates of Reliability/Validity of the Individual Items of the Question Paper on Compulsory Mathematics.*

Question Item No.	Short Description of the Question-items	Coefficients of Correlation between Item-score and Aggregate score as Reliability/Validity Estimates				
		Point Biserial	Tetra-Choric	Yule's Coeff. of Asson.	Yule's Coeff. of Collgn.	Sheppard Coeff.
(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Arithmetic :					
1	Simplification	.48	.67	.77	.47	.86
2 (a)	L. C. M. Problem	.37	.47	59	.31	.74
(b)	Profit & Loss Problem	.43	.61	.72	.41	.40
or (c)	Square-root Problem	.46	.65	.75	.45	.94
(d)	Time & Work Problem	.60	.78	.86	.57	.96
3 (a)	Practice	.40	.58	.69	.40	.87
(b)	Fencing & Papering	.46	.65	.75	.45	.61
or (c)	Percentage Problem	.40	1.00	1.00	—	.94
(d)	Alligation Problem	.36	.01	.10	.01	.92
4 (a)	Time & Distance Problem	,62	.08	.14	.05	.66
or (c)	Stock & Share Problem	.68	.83	.90	.62	.64
	Algebra :					
5 (a)	Factorisation	.50	.77	.86	.56	.96
(b)	L. C. M. (Algebra)	.50	.72	.83	.52	.52
or (c)	Identity (Subsiitution)	.49	.67	.77	.47	.94
(d)	Equation	.52	,79	.87	.58	.18
6 (a)	Square-root (Algebra)	.57	.84	.91	.64	.72
(b)	Ratio & Proportiou	.48	.41	.50	.27	.55
or (c)	Cyclic Factorisation	.53	.42	.52	.28	.78
(d)	Problem on Equation	.52	.81	.88	.60	.84
7	Graph Drawing	.31	.84	84	.63	.96
	Geometry :					
8 (a)	Theorem 11 (Book I)	.50	.67	.77	.47	.93
(b)	Exercise on Above	.50	.65	.75	.45	.01
or (c)	Theorem 26 (Book II)	.36	.44	.53	.29	.85
(d)	Exercise on Above	.57	.57	.67	.38	.32
9 (a)	Theorem 16 (Book I)	.58	.80	.88	.56	.96
(b)	Exercise on Above	.65	1.00	1.00	—	.38
or (c)	Theorem 32 (Book III)	.73	.91	.95	.73	.85
(d)	Exercise on Above	.65	1.00	1.00	—	.27
10 (a)	Triangle Construction	.52	.76	.84	.55	.07
(b)	Locus Finding	.37	1.00	1.00	—	.07
or (c)	Inscribing a Triangle	.64	.75	.84	.54	.39

Now, to get scores of the candidates on a standard (criterion) test, we propose to take the internal test-examination as the criterion test of the candidates on the following considerations : In the first place, the achievements of candidates in the test examination are usually based on the teachers' assessment, whereas the achievements of candidates in the School Final examination have the possibility of being randomly measured by the examiners appointed by the authorities concerned. Secondly, the test examination is framed and conducted by the teachers themselves who have occasions : to test the ability of the students in many previous internal examinations. We may thus accept their assessments as more accurate than those of the examiners in a public examination. There may however, be one objection some bias may come into play in showing somewhat high or low scores of the candidates and that may not be insignificant. For we know that the candidates desiring to appear at the School Final examination are required to submit the statements of the headmasters of their respective schools regarding their performances in the internal test examination. But we believe this does not reflect on the validity and reliability of the internal qualifying tests, because the internal test is meant for obtaining some reliable pre-estimation of candidates' performances in the public examination.

In the present case, it is found that the marks scored by the candidates in the Internal Test examinations are mostly lower than their marks in the School Final examination. This shows that teachers testing their own candidates to be sent up for the Final examination apply more rigidly the several principles of examination, namely, consideration of the syllabus, the standard of teaching in class-rooms, and average intellectual level of their candidates. Hence perhaps it is not unreasonable to take the test examination marks of the candidates as the criterion scores for estimation of the validity of the paper.

It is under these considerations that we have taken the scores of the Internal Test and the School Final examinations of a small representative sample of eighty-one candidates. By calculating the product-moment correlation between the two sets of scores, we have found out a measure of validity of the full question paper. The columns 4 and 5 of Table 9, p. 72, show the data referred to here, and the coefficient of correlation representing the measure of validity of the full paper comes out to be $r_{1c}=0.57$, a value which is not sufficiently high for an achievement examination. On the face of it, the measure is thus not a satisfactory one and the reason is not far to seek. The low index of validity may be said to be a symbol of the defect of the question paper as a measuring instrument of the true mathematical ability—a fact which has already been borne out by the analysis of the question paper from other points of view.

We should not forget that strictly speaking, a single figure cannot be said to represent the measure of the reliability or the validity of an achievement test. Achievement examinations are usually regarded as self-validating in the sense that they are tailored to measure the products of well-defined objectives in training or education, and therefore, they serve as their own criteria. To know their accuracy of measurement in terms of an index of reliability and validity, the only way is their repeated application with gradual refinement till they can be finally accepted and adopted.*

17. STANDARDIZATION OF QUESTION PAPERS FOR A PUBLIC EXAMINATION

17.1. Achievement Tests and their Standardization :

The two previous sections have been devoted to study the reliability and validity of question papers of a public examination, and the estimation of these indices of a particular question paper, namely, that of Compulsory Mathematics of the year 1952, of the School Final examination of West Bengal Board of Secondary Education. The question paper did not include many items of the objective type but the types of question-items contained in it have been traditionally considered very suitable by the paper-setters and the teachers as well, for measurement of achievements of students in the subject. The cases are of course more or less similar with the question papers on other subjects of the examination.

Achievement tests on any subject, it should be noted, are tests which aim at measuring the skills and information acquired in the course of training in the subject. Question-items for achievement tests on a school or college subject are generally selected from those items which the teachers have found to be good indicators of achievement in a subject in a course of instruction on that subject. Consequently, if a group of competent teachers agree that a particular question-item possesses such quality, then it can be taken as a relevant question-item of an achievement test on the subject. All the various question-items forming an achievement test on a subject should be based upon a careful study of the curriculum contents, the formulated objectives of the examination and on satisfactory results of responses of an adequately sampled student population. While trying a set of question-items on a group of students and analysing the scores obtained by different individuals, one should consider all sorts of comparisons with respect to age, class or grade or form, economic background, environmental conditions, etc., of the students, to ensure some desirable standard of the test as a whole.

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* *cf.* Guilford J. P.,—*Psychometric Methods.* McGraw Hill, U. S. A. (1954), Chapter 14.

Can we assume this quality of 'good indicators of achievement' in the subjects to be possessed by the types of question-items traditionally used for setting the question papers of the Board or University examinations ? A comparison of the structures of question papers used for measurement of achievement in mathematics, with those of standard tests of objective type used for measurement of psychological traits or aptitudes, led us to explore what methods could be applied for estimating the reliability and the validity of the question paper under investigation. It is not known whether the estimations have been satisfactory, but all we have been able to gather is that it is impossible to have a question paper of high reliability and validity unless it is composed of well-tried and standardized question-items. Hence to ensure the reliability and validity of a question paper in a public examination, there is perhaps no other way than to have a pool of standardized question-items on different subjects in which the examinations are held. A Board should devote to prepare suitable questions which may with refinement attain the status of standardized achievement tests.

17.2. Methods of Standardization :

Standardization of a test or a set of questions in any given subject imposes a primary condition, which is that the test items must be of the objective type. Without this essential quality of objectivity no question-item should be included in a standardized test. Today the question-items on any subject in a public examination are not wholly amenable to standardization because they are not of the objective type and hence the determination of their reliability and validity is very difficult and is bound to be tentative in character. This is not all ; standardization of a test is a laborious and expensive operation. As summarised by Edward B. Greene (1952), such a programme includes a large number of steps of which some important ones are : (*i*) To decide specifically what is to be measured and how. This step will give the test a clear objective. (*ii*) A large number of sample items on tests are secured in order to gurantee a good coverage of the area to be tested. (*iii*) The items are to be tried out on a sizable and representative group of candidates having known characteristics. This step will help to find out what value a test has in a particular situation. (*iv*) The scores to each item are to be analysed to determine such attributes as content, relation to other items, relation to criteria of success, and the difficulty value. (*v*) Third and fourth steps above are repeated on a new group of candidates. This step is necessary to avoid chance or random errors in the first tryout. (*vi*) Then final revision is made to yield two equivalent forms of highly important items, with the test arrangement for more administration and scoring. (*vii*) Standard results are secured at last by testing large groups of candidates selected as representative samples.

The enormous number of candidates in a public examination, the heterogeniety of their age groups and levels of intelligence, differences in the teaching environments of candidates, etc., create difficulties which have to be overcome before question-items for a public examination are to be standardized. The diverse factors affecting standardization have been very ably summarised by Willard C. Olson (1957).* 'A standard test attempts to measure the common elements in instruction under widely varying conditions in a roughly comparable culture and opportunity for schooling....In the light of our present knowledge of development, the standard tests give descriptions of level and growth which can be helpful in understanding students and the educational process. Then results will be affected by individual differences in maturation in students, by sex, by socio-economic background, by motivation, and other factors. Since the standard tests emphasize *common* factors, other instruments are needed to describe those which are *unique* to a given time and place.' The common factors can be detected by the 'method of factor analysis' and other tests can be constructed to measure these unique factors.†

Some practical steps and precautions to be taken for construction of a standardized set of question-items, as noted by Kenneth L. Bean (1953), are summarised as follows : There should be more or less uniform instructions for administration and scoring procedure, which are to be formulated and finalised in the course of repeated trials of the test items. Only important topics and skills are to be included and that ambiguities and chance factors are to be eliminated ; the essential criterion of inclusion and exclusion being the agreement of administrators or teachers on the relevancy of the contexts. The personnel constructing a standardized test will commonly try out many question-items and discard those items that are not applicable or do not differentiate between abilities. A standardized test is administered under conditions in which all the relevant factors such as, allotment of time, instructions of the test-administrators etc., are always uniform.

In order to secure standard conditions of test administration the test constructor should provide detailed directions for administering each newly developed test. The formulation of directions is a major part of the standardization of test. Such directions extend to the exact materials employed, time limits, written instructions for the size and shape of the answers, ways of handling queries from subjects and use and limitations of drawing and other instruments, tables, graphs, charts for answering the question items. A test must include as many specific instructions for keeping conditions uniform as far as practicable. If too much is left to the examiner's judgement the standard conditions of administration cannot be achieved properly. Another important characteristic of a standardized test is that it must have uniform scoring key. The tests should be of such a nature that the examiner may not find it difficult to assess the correct value of the responses.

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* Educational Studies and Documents No. 26, UNESCO, 1957.

† A subjective analysis indicates that probably four independent common factors are at work for answering question-items on Mathematics : verbal information, reasoning, spatial imagery, and number relations, and a standardized test on mathematics should account for all the four common factors. This standardization property of a test can be examined by the method of factor-analysis.

The next important feature of a standardized test is 'adequate norms.' Without norms, test scores cannot be interpreted. A candidate's score can be judged only by comparing it with scores obtained by others. As its name implies, a norm is the normal, or average performance. Raw scores are meaningless until they are evaluated in terms of a suitable set of norms. For standardizing a test, it must be administered to a large representative type of subjects for whom it is designed. This group, known as the 'normative' or 'standardization' sample, serves to establish the norms. Such norms indicate not only the average performance but also the relative frequency of varying degrees of superiority and inferiority. The specific ways in which such norms may be expressed, determine the designation of a candidate's position with reference to the normative sample. Last but not the least important aspect of a standardized test is a high degree of validity and reliability. A standardized test should have both its validity and reliability verified before its printing and distribution for examination purposes.

17.3 Problems of Standardization :

In our country standards of instruction and teaching environments including the teaching personnel widely vary from school to school, and from place to place. For example, candidates coming from a school in a city like Calcutta are found to differ in many respects from those coming from a very remote village in the country-side. These variations may prove stumbling blocks in the way of construction and standardization of achievement tests.

There are also other conditions which are necessary for standardization, but almost all of them are conspicuously absent in the present system of examination. We discussed in a previous section that the syllabus of studies for public examination is brief and rather cryptic in nature ; it does not mention the topics and sub-topics in detail ; such a syllabus is not very helpful in framing objective type of questions in a subject. Then again, numerous books on a single subject for an examination create another type of difficulty. Different authors' treatment of the subject-matter based upon a defective syllabus naturally create subjective differences between one text book and another and disturb the uniformity of instruction from school to school. Such difficulties may be partially overcome if a single standard text book on a subject written by a board of subject experts and based upon a detailed syllabus of the subject is introduced in all schools to bring about uniformity of instruction and facilitate standardization of question-items.

Unsatisfactory results in public examinations focus the attention of educational authorities and the public not only to the defective system of examination but also to the system of education itself. The lack of uniformity in abilities and skills among candidates, to which we have already referred may be overcome to facilitate standardization, if all schools make sure that candidates which are sent up for public examination are properly equipped and well informed to do full justice to the questions on which their performances will be the basis of final ranking. It is evident that under the present circumstances construction of standardized question-items of satisfactory reliability and validity for public examinations involving a large number of candidates is very difficult.

There is another factor which is important and must be kept in mind. Even now educational administrators and authorities of public instructions have not begun to swing to objective type of questions in place of the traditional essay type. Unless that is done the question of standardization of achievement tests cannot be solved. But it should however be noted in this connection that educationists both in India and abroad, while realising the importance of objective type of tests are not in favour of doing away with traditional essay type questions altogether, particularly in scholastic tests which are done through public examinations. The fact is, both the types of questions have their merits and limitations. Whereas objective tests are quick to administer and good for securing uniformity of assessment, and are very suitable instruments for measuring a candidate's precision and accuracy of statement, and analytical understanding of principles and items of information, the essay type questions also have certain very valuable qualities. Such questions are very good for measuring a candidate's power of synthesis, power of logical presentation of facts having cause and effect relation among them. These are very useful qualities in a candidate and therefore they should be measured before final ranking. Although the essay type questions are not easily amenable to standardization, yet all educationists feel that such questions should not be dispensed with altogether.

It is in view of these considerations that in the Seminar on Examinations in the year 1956 at Bhopal, India, it was proposed that in public examinations, objective type of questions should be introduced in each paper along with essay type questions. To bring about uniformity of assessment and some amount of objectivity, detailed instructions to examiners should be given and some questions requiring short answers should be introduced.* The gradual inclusion of the objective type of questions in the public examinations would also seem to increase the objectivity and reliability of the examinations and at the same time would make them less costly and more practicable as the number of candidates continue to increase.

17.4. Scope of Research in Standardization :

Investigations should be made first at the school and college levels in respect of students' responses in internal examinations. In other words, we must start from the beginning.

Principles of construction of the syllabus in a given subject, must be reflected in the contents of the syllabus. After that is done the scope of the subject area bounded by the syllabus must be made clear both to teachers and the students. It is then and then alone many of the vagaries of test construction and paper-setting may be things of the past.

On the other hand, there must be checking and screening at every stage of instruction to see that the student population for which a battery of tests in a particular subject has to be constructed has come upto the standard through proper study, experience and training and has acquired that degree of ability which the proposed test demands.

Before anything like standardization of final tests is possible, constant refinement is essential in respect of these two entities, namely, the subject of study and the student population.

There is much scope of research in both of these fields. Defining and analysing and systematising the subject matter of study must go on through application of tentative tests to the given population through internal examinations. Quite naturally, reorientation of the entire procees of teaching may be not only necessary but inevitable. Only patient and resourceful teachers can stand this ordeal.

At the other end, utmost care must be taken to see that under this process of tentative testings, a section of the student population may not be hastily thrown out as unfits. For this purpose Special Courses of instruction may have to be undertaken or newer methods of teaching may have to be introduced to bring the population in a class-room to attain a minimum level of desired ability. Such research units must work at every school or college and their findings and conclusions should be co-ordinated, amended, refined and finalised by the Highest Education Authority, may it be a University or a Board.

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* "On the question of relative weightage to be assigned to the essay type and objective type questions when they are used in combination as instruments of evaluation, the Seminar is of the view that equal weightage be given to them. This is, however, arbitrary. The exact proportion in which the marks should be allocated to the objective and the essay type examinations for final evaluation in a particular subject can be determined only by research and experimentation. At a later stage the question of a proper scaling of marks obtained on the two types of examinations may be taken up."—*Report on the Seminar on Examinatious (1956), Bhopal, India. P. 30.*

17.5. Concluding Remarks :

Complete standardization of public examinations is neither possible nor desirable. If the aim is to raise the standard of education and examination then it is quite evident that a standardized set of questions which should be suitable for the entire population of School Final candidates of today is bound to be something below the desirable standard and hence the aim shall not be achieved. So under the existing circumstances it is necessary to conduct study and research on the performances of candidates in public examinations for some consecutive years with the formulated objectives of the examination in view in respect of several subjects. In near future, if at all, essay type questions cannot be dispensed with in public examinations, it is better to bring about objectivity in such questions and certain steps should be taken. In the first place, a question should be so worded that a candidate may know at once what is expected of him by way of either information or interpretation or appreciation. In the second place, in respect of each question-item, candidates must be clearly told on what basis and in what proportion their performances will be evaluated by the examiners ; and thirdly, for the convenience of evaluation by the examiners the total mark allotted to a question-item should be split into several parts of which each part refers to a particular aspect of the answer, such as correct information or correct spelling or logical presentation or correct grammatical construction in a question-item on language.

It is far more desirable to bring about conditions which would ensure greater objectivity and uniformity both in candidates' performances as well as in examiners' evaluation than to cherish the almost unattainable ambition of standardizing question-items on a dozen subjects for a quarter-million candidates. Prior to standardization both the objective type of questions and re-oriented essay-type questions should be introduced in internal examinations of schools and colleges and responses of candidates thereto should be analysed. Unless students get trained in responding to certain types of questions by their teachers it is never possible to get reliable. performances from the same candidates when they sit for a public examination.

PART VII

A COMPARATIVE STUDY OF PERFORMANCES IN MATHEMATICS AND LANGUAGES

18. LANGUAGES IN SCHOOL FINAL EXAMINATION

18.1. Question Papers and Syllabii in Languages :

Detailed study of achievements in Mathematics of School Final candidates of 1952 led us to a comparative study of performances in Mathematics and Languages. Only the total marks in individual papers will be taken into consideration and not the item scores in each paper. Languages occupy major space in the School Final examination in West Bengal, inasmuch as they cover 450 markes out of 800 of the aggregate marks in the whole examination. Moreover, like Mathematics, Languages are also compulsory subjects in which all candidates have to pass in order to come out successful in the examination. Thus it is evident that a comparative study of performances in Mathematics and Languages may reveal how far and how differently success in Mathematics and Languages contribute to the success in the examination. In West Bengal, a Schoool Final candidate of 1952 had to take examinations in three languages : English, Vernacular and a Classical Language. Distribution of marks and the number of papers for these language subjects are as follows :

(*i*) English consists of three papers ; Paper I and Paper II carry 100 marks each and Paper III is a half paper of 50 marks. The minimum mark for a simple pass is 36 percent, that is, 90 marks out of 250. In English—I, questions on English Prose text cover 75 marks and questions on Grammar carry 25 marks. In English—II, questions on Poetry text cover 50 marks and questions on independent composition carry 50 marks, which are distributed in the following manner : Substance writing—15 marks ; Writing a letter on a familiar topic or experience—15 marks, Translation of a Vernacular passage into English—20 marks ; English—III consists of questions on a story book prescribed by the Board. Candidates are required to write stories of the text book in their own words as far as possible.

(*ii*) Major Vernacular covers two papers of 100 marks each. The minimum mark for a simple pass is 36 percent, that is, 72 marks for the two papers. Vernacular (modern Indian lauguages) Paper I consists of questions on Prose and Poetry texts prescribed by the Board ; in Paper II marks are distributed as follows : Questions on Grammar—25 marks, Essay on a familiar topic—25 marks ; A General Question of the essay type on a story book prescribed by the Board for Rapid Reading—25 marks, Translation of an English passage into Vernacular—25 marks.

(*iii*) Classical Languages ; that is, any one of the classical group, namely, Sanskrit, Pali, Arabic, etc, covers one paper of 100 marks. But the fact is that the vast majority of candidates offer Sanskrit. In our sample of 3717 candidates, only 321 offered classical languages other than Sanskrit. The paper consists of questions on a prescribed text book on Prose and Poetry and on Grammar and Translation from English to the classical language concerned. As 3396 candidates out of the sample total of 3717 have offered Sanskrit, we have separately studied the performaces in other classical languages.

18.2. Attainments in Mathematics and Languages :

For the sake of convenience of comparative study of attainments in compulsory mathematics with those in six papers on languages, namely English—3 Papers, Vernacular—2 Papers and Classical Language—1 Paper, we present the frequency distributions of scores in all the seven papers together in a tabular form (Table—11). For the sake of convenience of comparison English Paper III of 50 marks and scores thereon have been doubled and shown on the scale of 0 to 100 like those in other papers.

The Histograms of the frequency distributions of marks in different subjects are also shown in the diagrams that follow. The number of candidates securing pass marks less one, that is 35 or 29 marks as the case may be, and that securing the pass marks will also be found separately represented in the histograms (Figs. 5 and 6).

Some of the interesting points about the hierarchy of papers and subjects as revealed by this table and the diagrams are as follows : Of all the seven papers, six on languages and one on mathematics, we find that in English Paper II the percentage of failure being 58.5, is the highest and in Mathematics, it is 10.4, the lowest. In decending order of difficulty indicated by percentages of failures, the papers may be arranged thus :

(1) English-Paper II, (2) English-Paper I, (3) English-Paper III,
(4) Sanskrit, (5) Vernacular-Paper II, (6) Vernacular-Paper I,
(7) Mathematcs (Compulsory).

We may note that in Mathematics and Sanskrit the minimum score for a simple pass is 30 out of 100, but in the other five papers on

TABLE 11 : *Frequency Distribution of Scores in Languages and Mathematics.*

Class interval	Eng.—I		Eng—II		Eng.—III		Vernacular —Paper I		Vernacular —Paper II		Sans. & other Classics		Maths. (Comp.)	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
00—09	43	*1.1*	57	*1.6*	41	*1.1*	—	...	5	*0.1*	20+ 5	*0.7*	72	*1.9*
10—19	242	*6.5*	327	*8.8*	142	*3.8*	21	*0.6*	33	*0.9*	144+11	*4.2*	121	*3.3*
20—29*	675	*18.2*	1114	*30.0*	425	*11.4*	199	*5.3*	227	*6.1*	413+20	*11.6*	190	*5.2*
*30—35†	472	*12.7*	677	*18.1*	387	*10.4*	213	*5.7*	204	*5.5*	785+63	*22.8*	451	*12.1*
†36—45	1639	*44.1*	1345	*36.2*	1783	*48.0*	2089	*56.2*	1877	*50.6*	988+80	*28.7*	862	*23.2*
46—55	526	*14.1*	167	*4.5*	741	*20.0*	983	*26.5*	1007	*27.1*	638+70	*19.1*	841	*22.6*
56—65	117	*3.2*	27	*0.7*	183	*4.9*	187	*5.0*	316	*8.5*	244+44	*7.7*	576	*15.5*
66—75	3	*0.1*	3	*0.1*	15	*0.4*	25	*0.7*	48	*1.2*	115+24	*3.7*	350	*9.4*
76—85	—	—	—	...	—	...	—	...	—	—	45+ 4	*1.4*	178	*4.8*
86—95	—	...	—	...	—	...	—	...	—	...	4+ 0	*0.1*	70	*1.8*
96—99	—	...	—	...	—	...	—	...	—	...	—	...	6	*0.2*
Total	3717	(100)	3717	(100)	3717	(100)	3717	(100)	3717	(100)	3396+321	(100)	3717	(100)
35† **29***	† 25	*0.7*	17	*0.4*	—	...	4	*0.1*	10	*0.3*	* —	...	**6**	*0.2*
36† **30***	†351	*9.4*	452	*12.1*	503	*13.5*	383	*10.3*	399	*10.7*	***318+31**	*9.4*	**127**	*3.4*

* Frequencies at 29 and 30 for Mathematics and Classics.

† Frequencies at 35 and 36 for English and Vernacular.

TABLE 12 : *Showing Mean Scores, Standard Deviations and Percentages of Passes and Failures in Languages and Mathematics.*

Papers	Full Marks	Pass Marks	Mean±S.D.	Number appearing	No. of Passes	Passes %	No. of Failures	Failures %
English—I	100	36	36.5±11.0	3717	2285	61.4	1432	38.6
English—II	100	36	31.7± 9.6	3717	1542	41.5	2175	58.5
English—III	100	36	39.6±11.5	3717	2722	73.2	995	26.8
Vernacular—I	100	36	43.0± 8.5	3717	3284	88.3	433	11.7
Vernacular—II	100	36	43.7± 8.7	3717	3248	87.4	469	12.6
Sanskrit	100	30	39.4±13.2	3396	2783	82.0	613	18.0
Other Classics	100	30	43.1±14.7	321	285	88.8	36	11.2
Mathematics	100	30	48.1±17.3	3717	3334	89.7	383	10.3

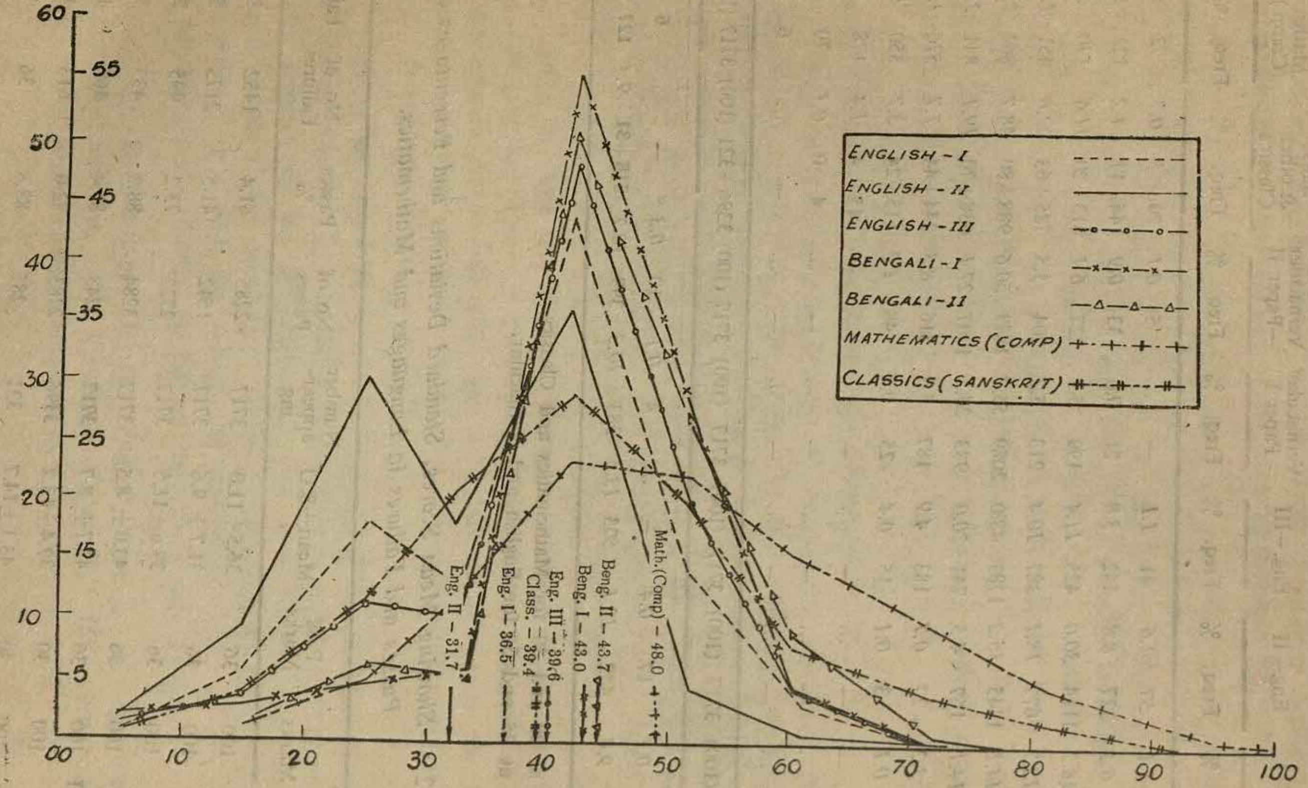

Fig. 5 : *Showing Relative Frequency Polygons of Scores in Mathematics (Compulsory), English—Paper I, II and III and Vernacular (Bengali)—Paper I and II and Classics (Sanskrit and other Classical Languages) of 3717 Candidates' in the School Final Examination, West Bengal, 1952.*

English and Vernacular, it is 36 out of 100. This difference in the scales is significant, because failures in Mathematics and Sanskrit lie in the range of 0 to 29, but failures in English and Vernacular lie in the range of 0 to 35. From this it may be observed that success in Mathematics or Sanskrit is definitely easier than success in either English or Vernacular. The truth of the statement is realised by a comparative study of highest scores in the papers. In the five papers on English and Vernacular we find that there is not a single student scoring in the range of 76 to 100. But in Mathematics and Sanskrit the number of cases above 75 is not insignificant. Comparison of the minimum pass mark, the mean score and the number of candidates clustering round the pass-mark especially reveals some interesting points.

In Mathematics the mean score is 48.1. A large number of candidates, 23.2 percent, falls in the range of 36 to 45 and the percentage of candidates in between 30 and 35 is 12.1. It shows that a larger number of students came out successful in Mathematics with rather poor performances, so much so that we do not find what we normally expect, namely, clustering of the highest number round about the mean score.

In English—II and in English—I, the picture is just the reverse. In English—II, the mean score is 31.7 and the minimum pass mark is 36. Strangely enough, the candidates did not cluster much round the mean score but round 36, whereas the percentage of failures in the paper is as high as 58.5. It clearly shows that candidates in general are not at all properly equipped and the picture is somewhat abnormal in that the candidates are mostly in the close neighbourhood of the pass mark in the paper. In fact, out of 41.5 percent of successful candidates as many as 36.2 percent stand in the range of 36 to 45. Table 11 shows comparative figures for different levels of achievement in Languages, paper by paper, along with those in Mathematics.

In Table 12, the mean scores, the standard deviations and the number of passes and failures in all the seven papers on Mathematics and Languages are given. The table shows that the standard of performance in Mathematics is definitely better than that in any of the Languages. Vernacular comes next to Mathematics of which the average score is 48.1 as against 43.4 in Vernacular. Judged by the mean scores, performances in Sanskrit (mean score : 39.4) are poorer than those in other Classical Languages (mean score : 43.1) or in Vernacular or in Mathematics ; performances in English stand lowest among languages and the mean score is 35.9. Although the pass-mark for Compulsory Mathematics and the Classical Languages is the same (minimum 30 percent), scoring in Sanskrit is found to be low compared with that in

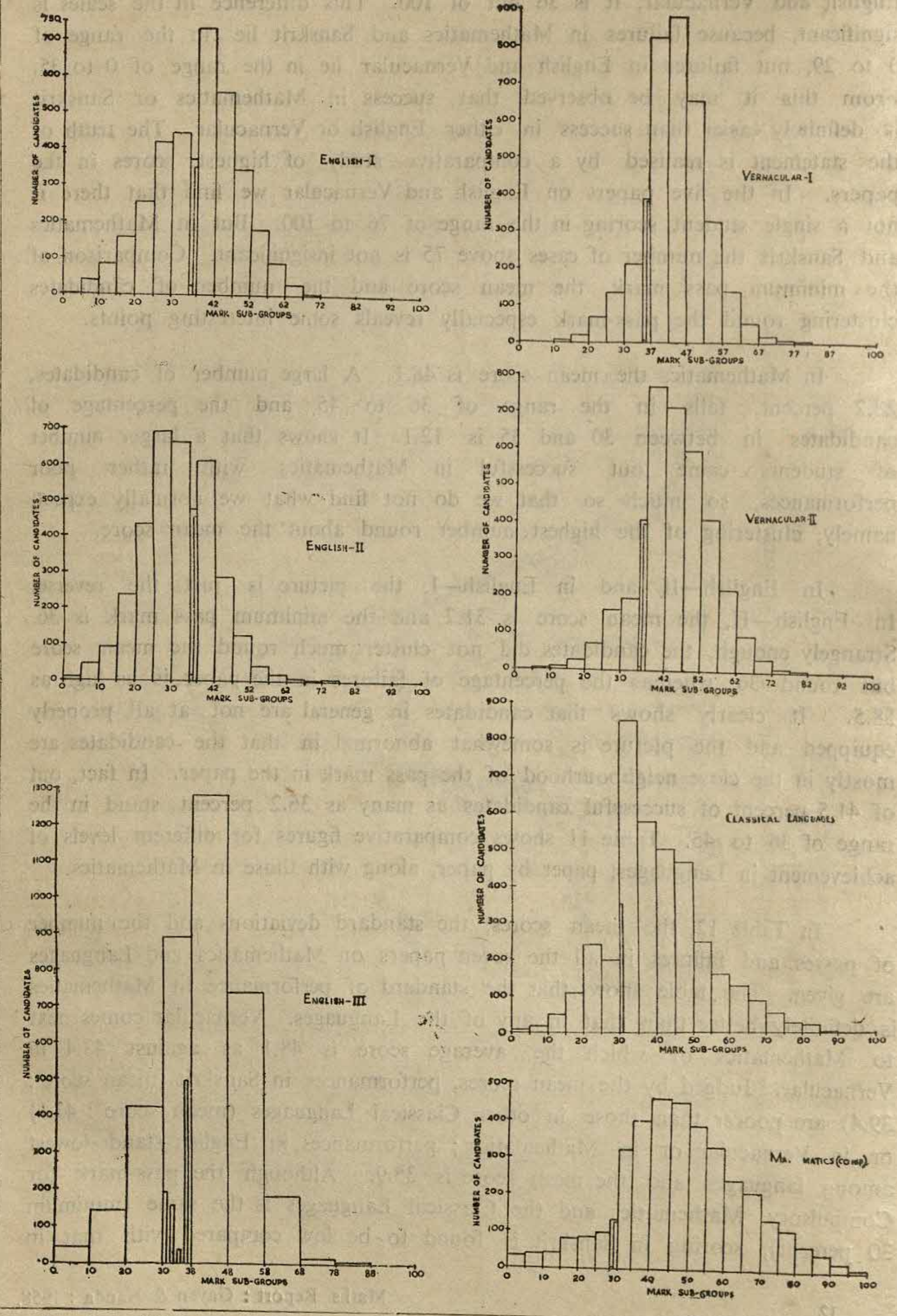

Fig. 6 : Histograms of Marks in Mathematics (Comp.) and Language Papers.

Mathematics, and lower is also the percentage of passes. It shows that the candidates do not pay adequate attention to the study of classical languages which is the parent stock of most of the Indian vernaculars. The fact goes a great way to explain the lack of proficiency in mother tounges which is so common amongst the present-day students. Considering that Sanskrit Grammar, Geometry and some parts of Mathematics require similar mental faculty for their understanding and mastery, one would naturally expect similar attainments in both the subjects. This has been the case here. Poor performances in Sanskrit, as well as in Geometry, (see Appendices) indicate that the group under survey had not devoted to the logical parts of these very important subjects.

When we compare the percentage of passes in Language papers with that in Mathematics we also find that only 41.5 percent candidates have passed in English—II, 61.4 percent, in English—I and 73.2 percent, in English—III. Thus in this respect also English stands lowest. Sanskrit and Vernacular—I and II, have nearly 90 percent of passes and thus they stand almost on equal levels with Mathematics in which the percentage of passes is 89.7. We have noted earlier that in Mathematics, 30 is the minimum pass mark, whereas in English and Vernacular the minimum pass mark is 36 percent. Hence it may be said that the standard of success in Vernacular is rather higher than that in Mathematics. One factor however, explains this peculiar situation. Standard deviation in Mathematics is the highest (17.3) but the standard deviations in Vernacular papers are respectively 8.5 and 8.7. This means that there is considerable spread of scores in Mathematics, whereas in Vernacular papers scores are rather clustered round the average marks. The tendency of marks to cluster round the pass marks produces an appreciable effect on percentage of passes. For instance, the average score in English—I is 36.5, and so assuming the frequency distribution to be symmetrical, we may infer that the percentage of passes will be just greater than 50; but here it is 61.4. It may be stated accordingly that at least 5 percent of students passed due to the leniency of examiners.

18.3 Frequency Distribution of Scores in Achievement Examinations :

There is a common belief that the frequency distributions of marks in examinations (scholastic tests) are usually 'normal'. In fact most workers in the field of educational statistics utilize this assumption in their studies. But in achievement examinations involving a large number of candidates of heterogeneous ability, the distributions would almost certainly appear with many irregularities—usually very high or very low frequencies at particular points on the scale, the points corresponding to marks of different grades of success. It has been found that such frequency distributions are often non-normal,

TABLE 13 : *Showing Comparative performances of Different Groups of Candidates in Different Papers*

	Regular			Private			All Candidates		
	Mean	S.D.	P. C. of Passes	Mean	S.D.	P. C. of Passes	Mean	S.D.	P. C. of Passes
BOYS									
	(N=3122)			(N=464)			(N=3586)		
Maths. (Comp.)	49.0		90.7	41.7		82.9	48.1		89.7
English—I	36.8		52.5	33.0		50.1	36.3		60.9
„ II	31.9		41.9	29.3		32.8	31.6		40.7
„ III	39.8		73.7	37.8		69.1	39.6		73.1
Vernacular—I	43.2		89.3	40.4		79.5	42.8		88.1
„ II	44.0		87.7	40.5		83.2	43.5		87.1
Sanskrit	40.1		84.9	32.7		69.9	39.2		82.8
Other Classicals	44.4		91.2	41.2		94.4	43.7		91.8
GIRLS									
	(N=98)			(N=33)			(N=131)		
Maths. (Comp.)	52.6		92.8	42.8		77.1	50.0		88.6
English—I	42.8		81.8	36.0		63.6	42.6		76.9
„ II	37.1		68.0	32.5		51.6	35.9		63.8
„ III	41.8		83.5	34.6		57.6	40.0		76.9
Vernacular—I	49.3		97.9	43.3		91.0	47.8		96.2
„ II	50.1		97.7	41.7		87.9	48.0		95.4
Sanskrit	22.2		93.2	42.4		91.7	50.1		92.9
Other Classicals	42.2		98.1	39.0		73.9	41.2		97.9
ALL BOYS & GIRLS									
	(N=3220)			(N=497)			(N=3717)		
Maths. (Comp.)	49.1	±17.06	90.8	41.8	±14.09	82.5	48.1	±17.30	89.7
English—I	37.0	±11.03	63.1	33.2	±10.02	51.0	36.5	±11.02	61.4
„ II	82.1	± 9.60	42.6	29.5	± 8.80	40.7	31.7	± 9.55	41.5
„ III	40.0	±11.54	74.0	37.8	±10.78	68.3	39.6	±11.46	73.2
Vernacular—1	43.4	± 8.49	89.6	40.6	± 8.14	80.2	43.0	± 8.50	88.3
„ II	44.5	± 8.64	88.0	40.5	± 9.19	83.5	43.7	± 8.72	87.4
Sanskrit	40.38	±13.29	85.0	33.0	±14.90	68.6	39.4	±13.18	83.0
Other Classicals	43.9	±15.16	89.0	40.5	±12.75	88.2	43.1	±14.69	88.8

Some Observations :

1. Pass-mark in English and Vernacular is 36%, and that in Mathematics is 30%. Here English Paper III averages are shown on a full paper basis. It is a half paper of 50 marks.
2. Regular Girl students are found to show superiority in their performances. Private Girl students are slightly inferior to Boys Regular in English—III.
3. English Paper II may be said to test real ability to write English Language. Vernacular two papers are alike in difficulty and easier than English Papers.

and must be represented by suitable non-normal curves. One of the factors contributing to this non-normality is, perhaps the leniency or otherwise of the examiners for cases in the neighbourhood of the critical point (the border point between success and failure) on the mark-scale. The frequency distributions of this study also indicate presence of such bias. We have given separately the frequencies for pass marks and for the marks immediately preceding that, to clearly bring out this point (Figs. 5 and 6). The distributions have been distorted by this factor into bimodal ones, so that strictly speaking, one cannot have any of the well-known frequency curves for such data. We can get the undisturbed original frequency distribution by cutting off, so to say, a fraction of the frequency at pass mark less one and adding it to the frequencies for the pass marks and for marks above that, if necessary.

Since the mean score is the highest in Compulsory Mathematics, when the pass mark is 30, it might be supposed that the percentage of passes will be much higher for Compulsory Mathematics than for any other paper excepting Classical Languages. This, however, is not found to be the case. The percentage of passes is about 90 for both Compulsory Mathematics in which the minimum pass mark is 30 and the two Vernacular papers in which the minimum pass mark is 36.

The reason why the percentage of passes for the two Vernacular papers is about equal to that for Compulsory Mathematics, in spite of the higher mean score and the lower pass marks for the latter, is to be sought in the figures for the standard deviations. Variability of marks, as measured by standard deviation, is by far the highest for Compulsory Mathematics and this tends to counter-balance the above two factors.

The greater variability of marks in Compulsory Mathematics, in spite of the unsatisfactory types of questions as discussed earlier (e. g. questions on elementary book propositions in Geometry), also shows, in a certain sense, that Mathematics is the best discriminator of ability. This is one of the reasons why we have given so much attention to this paper. We further see that the relative weights of different subjects as are now being used, that is 250 for English, 200 for Major Vernacular, and 100 for Compulsory Mathematics are very probably far from those which would be ideal from the point of view of the theory of scholastic tests. We have already discussed a similar problem in connection with the relative weights of the three branches: Arithmetic, Algebra and Geometry; and the methods of obtaining optimum weights that would lead to a maximum discrimination among the candidates have been described and illustrated. Similar methods would apply to determine the relative weights of different subjects of the School Final Examination (see Technical Appendices).

TABLE 14 : *Showing Average Marks Scored by Different Groups of Candidates in Different Papers.*

	English			Vernacular		Classical Languages		Compulsory Mathematics
	I	II	III	I	II	Sanskrit	Others	
Boys (Regular)	36.8	31.9	39.8	43.2	44.0	40.1	44.4	49.0
Girls (Regular)	42.8	37.1	41.8	49.3	50.1	52.2	42.2	52.6
Boys (Private)	33.	29.30	37.8	40.4	40.5	32.7	41.2	41.7
Girls (Private)	36.0	32.5	34.6	43.3	41.7	42.4	39.0	42.8

TABLE 15 : *Frequency Distributions of Marks in Major Vernaculars—Paper I and Paper II.*

Marks Sub-Group	Bengali		Hindi		Urdu		Manipuri		Nepalese		Other Languages		Total	
	I	II	I	II	I	II	I	II	I	II	I	II	I	II
0— 4	—	—	—	—	—	—	—	—	—	—	—	1	—	1
5— 9	—	4	—	—	—	—	—	—	—	—	—	—	—	4
10—14	3	7	—	—	—	—	—	—	—	—	1	1	4	8
15—19	17	24	—	—	—	—	—	1	1	—	—	—	17	25
20—24	58	68	3	—	1	—	—	—	—	—	2	2	64	70
25—29	133	152	—	2	—	—	—	—	—	—	2	3	135	157
30—34	202	179	3	3	—	—	—	1	—	—	4	11	209	194
35—39	802	828	20	22	4	2	1	—	—	—	5	7	832	859
40-44	892	718	27	26	1	4	1	3	—	—	12	6	933	757
45-49	687	628	19	12	4	5	1	—	3	1	10	3	724	649
50-54	466	462	11	17	8	2	—	—	—	—	8	5	493	486
55-59	164	275	5	8	3	2	—	—	—	1	4	4	176	290
60-64	79	119	8	5	3	3	3	—	1	1	4	5	98	133
65-69	11	44	2	2	1	4	—	1	—	1	1	3	15	55
70-74	13	17	—	1	1	4	—	—	—	—	—	1	14	23
75-79	1	3	—	—	—	2	—	—	—	—	—	—	1	5
80-84	—	—	—	—	2	—	—	—	—	—	—	1	2	1
Total	3528		98		28		6		4		53		3717	

18.4. Comparative Study of Performances of Boys and Girls :

A comparative study of performances of Boys and Girls belonging to both Regular and Private categories in the seven papers on Languages and Mathematics might be of interest. In Tables 13 and 14 comparative figures are given to show the quality of performances of the four categories of candidates. In general, girls have done better than boys. Regular girls score about 6 marks more in average than regular boys, except in English—III, where this figure is 2, and in Compulsory Mathematics where it is 3.6. The Tables show that regular girls have done better than regular boys in respect of all the seven papers on Mathematics and Languages. Better performance of private girls is also observed in respect of all the papers except in English—III. It may be pointed out that as there are only 33 private girl candidates these observations may not be so reliable.

Regular boys score better marks than private boys in all Language papers, and in Compulsory Mathematics. The average scores of regular girls are also 5 to 10 marks more than those of private girls in all the papers. It should be remembered however that some girl candidates take up Compulsory Mathematics instead of Arithmetic and Domestic Hygiene, which is a subject for girls only. So girls who offer Mathematics are expected to be good in the subject, specially when only 20 percent of them are offering Compulsory Mathematics. That is why, in each of the statement above, the term Girls should mean those offering Compulsory Mathematics. We should note here that boys appearing as private examinees might have had more of schooling than girls appearing as private candidates. This may serve to explain why the superiority of girls over boys is less when both are private candidates.

18.5. Comparative Study of Achievements in Mathematics and Vernaculars :

For approximately 98 percent of the candidates, the Major Vernacular is Bengali. The remaining 2 percent candidates had Hindi (97 examinees), Urdu (28), Manipuri (6), Nepalese (4), and other languages (31). The frequency distribution of marks in Vernacular Papers I and II for all these groups are given in the Table 15. Of the 97 candidates in Hindi, 14 secured 60-69 marks, 10 scored between 70-79 and only 9, that is, 9.3 percent of the sample (97) got distinction marks, 80 and above, which only 4.3 percent of the whole sample (3717) could secure. Among the candidates in other languages only one candidate got distinction marks. The next highest mark is as low as 63. The comparative performances of these different groups in Mathematics (Compulsory) may be seen in the figures of Table 16. In Table 17 below will be seen the performances of these candidates in their respective major vernaculars.

TABLE 16 : *Showing the Performances in Mathematics Compulsory of the Candidates of Different Vernacular Groups.*

Group	No. of Candidates	Average Mark Obtained	Percentage of Passes in Mathematics
Bengali	3528	48.1	90.4
Hindi	97	49.2	74.2
Urdu	28	41.7	64.3
Manipuri	6	40.2	83.3
Nepalese	4	37.0	50.0
Other Languages	52	48.9	86.5

TABLE 17 : *Showing Average Marks and Percentages of Passes in Different Major Vernaculars.*

Major Vernacular	No. of Candidates	Paper I		Paper II		Average Score in the Subjects
		Average Marks	Passing %	Average Marks	Passing %	
Bengali	3528	42.8	88.2	43.5	87.5	86.3
Hindi	97	44.7	93.8	45.6	94.8	90.3
Urdu	28	52.4	92.9	56.4	100.0	108.8
Manipuri	6	51.5	100.0	40.0	66.7	91.5
Nepalese	4	51.2	100.0	58.5	100.0	109.7
Other Languages	52	44.2	80.0	42.7	61.5	86.9

The last column of Table 17 shows that judged by the average score in the subject, that is, two Papers combined, the Vernaculars may be ranked in descending order of difficulty in the following manner : Nepalese, Urdu, Manipuri, Hindi and Bengali. The interpretation in terms of the relative difficulties on the basis of these and other figures of the table however is not likely to lead us far particularly because the sample size in two of the cases are as small as four and six.

PART VIII

ADDITIONAL MATHEMATICS IN SECONDARY SCHOOLS AND MATHEMATICS IN COLLEGE COURSES

19. ACHIEVEMENTS IN ADDITIONAL MATHEMATICS

19.1. Introduction :

The study of performances in Additional Mathematics of the School Final candidates of 1952 in West Bengal is a logical sequel to our study of achievements of candidates of the same year in Compulsory Mathematics.

Additional Mathematics has some special significance of its own. First, as an optional subject at the School Final stage it affords to satisfy the special interest and aptitude of a candidate in the subject. Secondly, any additional subject at the High School stage gives a student an opportunity for the first time for specialisation. Thirdly, Additional Mathematics has special importance for those who like to take up the General Science courses or the Technology courses at the collegiate stage.

A good many students may choose Mathematics as an optional subject for it is a good mark-getter and not because they like to take up Science or Technology courses in their college career. But without the special interest in and aptitude for the subject none is prepared to run the risk, because Mathematics does not generally admit of wide distribution of marks as the language subjects do.

19.2. The Sample :

The sample scripts on Additional Mathematics taken for this study represent the performances of those candidates who alone offered Mathematics as an additional subject among the 3717 candidates whose achievements in Compulsory Mathematics have so far been the subject matter of our study.

Only 253 candidates out of this total of 3717 candidates are found to offer Additional Mathematics. We made a statement previously to the effect that Mathematics as a subject in collegiate education had been gradually falling into disfavour. Relevant data in this connection collected from the Annual Reports of the University of Calcutta for the last fifteen years remarkably substantiate the statement (see Section 20 next) and it is rather unfortunate that this tendency has been there even in the School Final stage.

In a sense this sample of 253 students is fully representative of the population of candidates offering Additional Mathematics in 1952, and it can reasonably be considered as a ten percent stratified random sample since the group of 3717 candidates in Compulsory Mathematics we started studying in Section 2 is one such for the whole population of students of the year.

19.3. The Syllabus for Additional Mathematics, 1952 :

The course in Additional Mathematics includes, in addition to the syllabus for Compulsory Mathematics (see Ante pp. 9—11), the following topics :

(*a*) **Arithmetic :** Compound Interest, Exercises in the Metric System ; Approximation to a specified degree of accuracy including Contracted Processes.

(*b*) **Algebra :** Quadratic Equations with one unknown quantity ; Extraction of Square Root ; Graphs of Pure Quadratic Equations (excluding constructions with different scales along two axes) ; Arithmetical and Geometrical Progressions ; Elementary Laws of Indices.

(*c*) **Geometry :** THEORETICAL : Proportion : Similar Triangles. (*i*) If a straight line is drawn parallel to one side of a triangle, the other two sides are divided proportionally ; and the converse. (*ii*) If two triangles are equiangular, their corresponding sides are proportional ; and the converse. (*iii*) If two triangles have one angle of the one equal to one angle of the other, and the sides about these equal angles proportional, the triangles are similar. (*iv*) If a polygon is divided into triangles by a line joining a given point to its vertices, any similar polygon can be divided into corresponding similar triangles. (*v*) The ratio of the areas of two similar triangles, or of two similar polygons, is equal to the ratio of the squares on the corresponding sides. (*vi*) The internal bisector of an angle of a triangle divides the opposite side internally in the ratio of the sides containing the angle ; and likewise the external bisector externally. PRACTICAL : Simple cases of the construction of circles satisfying given conditions. Construction of regular figures of 3, 4, 5 or 6 sides in or about a given circle. Construction of a square equal in area to a given rectangle.

(*d*) **Trigonometry :** Measurement of angles ; Sexagesimal and Centesimal measure ; Circular or Radian measure ; Trigonometrical Ratios for angles less than a right angle ; Trigonometrical Ratios for 0°, 30°, 45°, 60°, 90° ; Simple Problems in heights and distances.

The distribution of marks shall be as follows :

(*i*) Arithmetic—30 marks,
(*ii*) Algebra—25 marks,
(*iii*) Geometry—30 marks,
(*iv*) Trigonometry—15 marks.

19.4. The Question Paper on Additional Mathematics, 1952 :

The question paper on Additional Mathematics covers some higher courses in Arithmetic, Algebra, and Geometry, in addition to the syllabus of Compulsory Mathematics, which all male candidates in the School Final Examination, West Bengal 1952, had to offer. Besides, rudiments of Trigonometry have been introduced in the curriculum of this paper for the last several years. The question paper to which reference has been made is reproduced here in the following pages :

BOARD OF SECONDARY EDUCATION. WEST BENGAL

SCHOOL FINAL EXAMINATION, 1952

ADDITIONAL MATHEMATICS

TIME—3 HOURS FULL MARKS—100

The figures in the margin indicate full marks. The candidates are required to give their answers in their own words as far as practicable.

1. Find, correct to five places of decimals, the value of:

$$\frac{1}{2\times5}+\frac{2}{2^2\times5^3}+\frac{3}{2^3\times5^5}+\frac{4}{2^4\times5^7}+\cdots\qquad 10$$

2. *Either,* Find the cost of surrounding a square field having an area of $432\frac{16}{25}$ square kilometers with a fence at the rate of Rs. 18. 12 as. per 100 feet. (one meter $=39.37$ inches). 10

Or, A sum of money is borrowed and paid back in two equal annual instalments of Rs. 882 each, allowing 5 per cent compound interest (interest being added yearly). What was the sum borrowed? 10

3. *Either,* A contractor agrees to supply $10\frac{1}{2}$ lacs of bricks for a particular work. His bricks cost him Rs. 42 per thousand to make and of these $12\frac{1}{2}$ per cent are rejected. How many bricks must he make in order to fulfil his contract, and what price per thousand must be put on those supplied in order to gain 25 per cent on his outlay? 10

Or, In 11 days 250 men working 9 hours a day complete 528 yards of a road which is to be one and a half mile long. How many additional men must be put in, in order that if all now work 10 hours a day, the road may be finished in 33 days more? 10

4. *Either,* *(i)* Find the square root of:

$$\left(x^2+\frac{1}{x^2}\right)^2-4\left(x+\frac{1}{x}\right)^2+12\qquad 5$$

(*ii*) Find the sum of the following series to n terms:

$$1\times3+3\times5+5\times7+7\times9+\cdots\qquad 5$$

Or, (*i*) Simplify:

$$\left(\frac{x^b}{x^c}\right)^{\frac{1}{bc}}\times\left(\frac{x^c}{x^a}\right)^{\frac{1}{ca}}\times\left(\frac{x^a}{x^b}\right)^{\frac{1}{ab}}\qquad 5$$

(*ii*) Show that the pth, qth, rth terms of a geometrical progression are in geometrical progression if p, q, r be in arithmetic progression. 5

5. *Either,* Solve:

(*i*) $\frac{x+3}{x-3}+6\left(\frac{x-3}{x+3}\right)=5$ 5

(*ii*) $4^{x+\frac{1}{2}}+4=36\,(2^{x-2})$ 5

Or, Draw the graphs of (i) $y=x^2$ and (ii) $2y-5x+3=0$ between the values of $x=-4$, and $x=4$ (with the same axes and the same scale of representation) and hence obtain the solution of the equation $2x^2-5x+3=0$. 10

6. If $4(a^2+b^2+c^2+d^2)=(a+b+c+d)^2$,

show that $a=b=c=d$. 5

7. *Either,* If two triangles have one angle of the one equal to one angle of the other and the sides about the equal angles proportional, prove that the triangles are similar. 10

In the equiangular triangles ABC and DEF, AM and DN are the medians meeting the sides BC and EF at M and N respectively. Show that the angles made by AM with BC are equal to the angles made by DN with EF. 8

Or, Prove that the internal bisector of any angle of a triangle divides the opposite side internally in the ratio of the sides containing that angle. 10

Prove by the above theorem and its converse that the three internal bisectors of the angles of a triangle are concurrent. 8

8. *Either,* Draw a circle of radius 3 cm. to pass through two given points A and B where AB = 4.8 cm. Find by calculation and measurement the length of the perpendicular from the centre upon AB. 12

(Traces and statements of construction only are required).

Or, Show that in any triangle, the feet of three altitudes, the mid-points of the sides, and the mid-points of joins of the orthocentre to the vertices lie on a circle. 12

9. *Either,* (i) Find the value of :

$$\cot^2 30^0 - 2\cos^2 60^0 - \tfrac{3}{4}\sec^2 45^0 - 4\sin^2 30^0 \qquad 7$$

(ii) A man $5\frac{1}{2}$ ft. high is seen from the distance of half-a-mile ; what is the angle that he subtends ? 8

Or, (i) Prove that,

$$2(\sin^6\theta+\cos^6\theta)-3(\sin^4\theta+\cos^4\theta)+1=0 \qquad 7$$

(ii) The shadow of a tower standing on a level plane is 60 ft. longer when the altitude of the sun is 30^0 than when it is 45^0. Find the height of the tower. 8

19.5. The Syllabus and the Question Paper :

Many of the characteristics of the question-paper on Additional Mathematics are found to be similar with those of the Compulsory Mathematics paper which we have already noticed. For example, the same practice of balancing of incompatible alternatives and similar bunching together and interlocking of the question-items are found to have been followed here. Regardless of difficulty values, question-items have been set as alternatives, so much so that in some cases the very purpose of the examination appears to have been defeated by the question-items concernd.

The question-item, Q. 4. Either *(i)*, is on Square Root of Indices, and the Q. 4 Either *(ii)*, is on Geometric Progression. The number of students not attempting the items is 50 and 130 respectively out of a sample total of 253. But at their alternatives, of which one is on Simplification of Indices, Q. 4 Or *(i)*, and the other on Geometric Progression, Q. 4 Or *(ii)*, the number of non-attempts are 215 (85 percent) and 237 (94 percent) respectively. In otherwords very few candidates appear to be acquianted with the principles involved in solving these problems. Another example may be given. In the case of Q. 3 Either, a problem on Percentage, the number of non-attempts is 221 (88 percent) ; whereas at Q. 3 Or, a problem involving Time and Work, the number of non-attempts is 86 (34 percent). Again in Q. 9 Either *(ii)*, the number of non-attempts is 205 (81 percent) and out of 48 who attempted, 44 have scored zero and the other 4 scored 6 to 7 marks out of 8 allotted on it. Thus for all practical purposes, these questions appear to have hardly helped in measuring the mathematical ability of the candidates. Almost all students seem to be innocent of the basic principles involved in these problems. Thus it may be said that the setting of such question-items has served no useful purpose.

TABLE 18 : *Showing Frequency Distribution of Total Scores in Additional Mathemaics.*

Score Interval	Frequencies		Percentages	
0 - 9	15		5.9	
10 - 19	39		15.4	
20 - 29	42	96	16.6	38.0
30—39	52		20.6	
40—49	33		13.0	
50 - 59	28		11.1	
60 - 69	18		7.1	
70—79	10	141	4.0	55.7
80—89	13		5.1	
90 -	3	16	1.2	6.3
Total :	253	253	100.0	100.0

TABLE 19 : *Showing a Comparison of Achievements in Compulsory and Additional Mathematics.*

	Additional Mathematics	Compulsory Mathematics
Mean		
Score	37.9	68.8
S. D.	21.9	17.3
Pass		
Per Cent	62.1	89.7
Correlation : $r=0.45$		

TABLE 20 : *Showing Number of Students (with Percentage) Scoring at Different Levels on the Question Items of Additional Mathematics Paper of the School Final Examination, 1952.*

Question-Items	Short Description	Number and Percentage (to Sample Total) of Non-Attempts and Attempts with Scorings at Diff. Levels of Item Marks Scales.										Percentage (to Total Attempts) for Scoring at Diff. Levels of Item Marks Scales.		
		Non-attempts		0—29		30—79		80—...		Total Attempts		0—29	30—79	80—...
		No.	%	No.	%	No.	%	No.	%	No.	%			
ARITMETIC		7	2.8	95	37.6	129	51.0	22	8.7	246	97.2	38.6	52.4	8.9
1.	Simplification.	32	12.7	137	54.2	2	0.8	82	32.4	221	86.4	62.0	0.9	37.1
2. *Ei.*	Measurement of Area	159	62.8	62	24.5	—	—	32	12.7	94	37.2	65.9	—	34.1
Or,	Compound Interest	149	58.9	82	32.4	—	—	22	8.7	104	41.1	78.8	—	21.2
3. *Ei.*	Percentage Problem.	221	87.4	21	8.3	5	2.0	6	2.4	32	12.7	65.6	15.6	18.8
Or,	Time and Work.	86	34.0	66	26.1	1	0.5	100	39.4	167	66.0	39.5	0.6	59.9
ALGEBRA		5	2.0	74	29.3	152	60.1	22	8.7	248	98.0	29.8	61.3	8.9
4. *Ei.* (*i*)	Square root of Indices.	50	19.8	26	10.3	1	0.4	176	69.6	203	80.2	12.8	0.5	86.7
(*ii*)	Geometric Progression.	130	51.4	60	23.7	—	—	63	24.9	123	48.6	48.8	—	51.2
Or, (*i*)	Simplification of Indices.	215	84.9	3	1.2	—	—	35	13.8	38	15.0	7.9	—	92.1
(*ii*)	Problem on G. P.	237	93.7	11	4.4	—	—	5	2.0	16	6.3	68.8	—	31.3
5. *Ei.* (*i*)	Simple Eqn. of Fraction.	140	55.3	47	18.6	—	—	66	26.1	113	44.7	41.6	—	58.4
(*ii*)	Equation of Surds.	177	70.0	51	20.2	—	—	25	9.9	76	30.0	67.1	—	32.9
Or,	Graph.	132	52.2	25	9.9	72	28.5	24	9.5	121	47.8	20.7	59.5	19.8
6.	Identity.	141	55.7	63	24.9	—	—	49	19.4	112	44.3	56.3	—	43.8
GEOMETRY		11	4.4	45	17.8	163	64.4	34	13.4	242	95.7	18.6	67.4	14.1
7. *Ei.*	Theorem of Book V.	132	52.2	23	9.1	2	0.8	96	37.9	121	47.8	19.0	1.7	79.3
	Rider on Above.	170	67.2	40	15.8	3	1.2	40	15.8	83	32.8	48.2	3.6	48.2
Or,	Theorem of Book V.	137	54.2	10	4.0	—	—	106	41.9	116	45.9	8.6	—	91.4
	Rider on Above.	195	77.1	42	16.6	—	—	16	6.3	58	22.9	72.4	—	27.6
8. *Ei.*	Construction Prob.	192	75.9	22	8.7	20	7.9	19	7.5	61	24.1	36.1	32.8	31.1
Or,	Theorem on 9-pt. Circle.	165	65.2	45	17.8	9	3.6	34	13.4	88	34.8	51.1	10.2	38.6
TRIGONOMETRY		44	17.4	62	24.5	100	39.5	47	18.6	209	82.6	29.7	47.9	22.5
9. *Ei.* (*i*)	Simplification.	172	68.0	31	12.3	—	—	50	19.8	81	32.0	38.3	—	61.7
(*ii*)	A Problem.	205	81.0	44	17.4	—	—	4	1.6	48	19.0	91.7	—	8.3
Or, (*i*)	Identity.	145	57.3	30	11.9	—	—	78	30.8	108	42.7	27.8	—	72.2
(*ii*)	A Problem.	166	65.6	36	14.2	1	0.4	50	19.8	87	34.4	41.6	1.2	57.3
FULL PAPER				96	37.9	141	55.8	16	6.3	253	100.0	37.6	56.0	6.4

Probable cause for such state of affairs may be that either the questoins are set outside the prescribed syllabus or teachers in class-rooms have not taken the trouble to teach those portions of the syllabus which cover these question-items. The validity of these type of questions in which the vast majority of students feel quite helpless may thus be reasonably questioned.

Moreover, balancing of alternatives of question-items of such widely different difficulty values can on no account be justified. We have already shown that in Compulsory Mathematics such unjustified balancing of alternatives has been responsible for unnecessary complication for candidates and the result has been that in choosing questions candidates, more often than not, have been unable to hit upon the right choice. The same disparity is here between the number of attempts and successes in respect of components of a group as we have seen in the case of Compulsory Mathematics. Accordingly our previous observations (see Ante p.23) on these points are also equally applicable in this case of Additional Mathematics Paper.

We believe that in setting question-items on Additional Mathematics a paper-setter should exercise much greater discretion and take utmost care in view of the fact that it is a paper for those who intend to proceed further with Mathematics ; hence the question of mechanically raising the percentage of passes does not arise. On the other hand, by no means, students should be scarred away by too difficult questions which are beyond their comprehension. Unfortunately the question paper under survey, is observed to suffer from both these types of defects.

In the West Bengal Board there is a rule that in a paper on any Additional subject 30 percent marks are deducted from the total score of a candidate and the remainder goes to his credit as the effective score in the paper, and it forms part then as the candidates' aggregate score in the examination. In otherwords, score of 30 marks out of 100 in an Additional subject does not help ranking of the candidate concerned. For example, by scoring 45 marks out of 100 marks in the paper on Additional Mathematics a candidate gets the benefit of 15 marks only. Of course, in considering his mathematical achievements, his actual score, that is 45 marks, is always taken into account. The principle behind this rule of deduction is based on the fact that a candidate could pass the School Final examination without offering any Additional subject whatsoever.

19. Analysis of Performances in Additional Mathematics :

In 20 out of 23 question-items (Table 20) the number of non-attempts ranges from 130 to 237 out of the sample of 253 candidates. This fact alone shows that most of the students who offered Additional Mathematics were considerably ill-equipped so far as the subject area covered by the prescribed syllabus was concerned.

The two factors, namely, the large number of non-attempts on the one hand, and on the other, a number of students with above 80 percent scores on some items have resulted in scoring of very high marks in the aggregate by a few (only 16) candidates. This shows that most of the students who scored 80 percent or above marks on particular question-items could not do justice to the other items of the paper. In otherwords, certain easy items in the question paper have been responsible for raising both mean score and the percentage of passes in the paper under survey. A good feature of the question-items is that most of them are found to be highly discriminating, as the item-scores generally lie at both the extremes of the mark scale. This is of course very desirable for a good question paper on Mathematics.

Comparison of scores in Compulsory and Additional Mathematics of this sample of 253 candidates reveals some very important facts. The aggregate score in Additional Mathematics of 96 candidates, that is, more than one-third of the candidates sampled, lie in the range of 0 to 29 ; whereas their corresponding scores in Compulsory Mathematics lie between 40 and 90. Hence it is quite evident that these students were allowed to offer Additional Mathematics in the final examination without any previous test on their abilities and achievements conducted by the teachers of their respective schools. It is these 96 students who have brought down both the mean score in this paper and the correlation between the scores in Additional and Compulsory Mathematics. Here this correlation is found to be $r=0.45$ only.

The mean scores in Compulsory Mathematics and Additional Mathematics are 68·8 and 37.9 respectively ; so that the performances in Additional Mathematics are not at all satisfactory. Comparison of the percentages of passes in the two papers shows that it is 89.7 in Compulsory and 62.1 in Additional Mathematics. The fact indicates that the 253 candidates who offered Additional Mathematics showed satisfactory performances in Compulsory paper but so far as Additional Mathematics was concerned they were definitely ill-equipped. We have already pointed out that reduction of 30 marks is made from the aggregate score in Additional subjects and only the remainder goes to the credit of the candidate. In the present case, mean score of 37.9 shows that on an average, only about 8 marks have gone to the credit of a candidate who offered Additional Mathematics. So the question naturally arises : Has it been worth the trouble taken by a candidate in going through some Additional subject like this for their School Final Examination ? For most of them certainly not. The above rule of reduction of 30 marks out of earned scores in an additional subject appears to be responsible for a lack of seriousness on the part of the teachers as well as the students. The previous practice of optionals within the curricular courses deserves as such, recommendation for reintroduction in the School Final stage.

20. PLACE OF MATHEMATICS IN COLLEGE EDUCATION

20.1. Mathematical Education at the Collegiate Stage :*

In previous Sections, we have noted more than once that mere success in the School Final examination does not mean a good ground-work in the fundamental mathematical principles and their applications. In Section 5, in particular, we have presented tabulation of performances and a bar diagram which go to show that with some rudimentary knowledge of the principles of Algebra and Geometry most of the students have come out successfull in Compulsory Mathematics for which 30 marks in the full paper is considered as the minimum pass mark.

This tempted us to a follow-up study of mathematical achievements of candidates at the next collegiate stage, that is in the Intermediate Arts and Science examinations in both of which candidates have the freedom to offer Mathematics as one of the elective subjects. Before we took up the study we felt that poor performances at the secondary stage are sure to have their reflections on their further mathematical education.

To begin with, we gather how many candidates of the Intermediate Examinations of 1955 of the University of Calcutta offered Mathematics at all. The figures which were made available to us by the Calcutta University authorities showed that in the I. A. Examination out of the total population of nearly 14,000 candidates only 270 (1.9 percent) students offered Mathematics as one of their electives, in spite of the fact that at the secondary stage all of them had secured pass marks.

This led us to a retrospective study of Statistical Reports of the Calcutta University on the results of I. A. and I. Sc. examinations since 1929. Records for 1942-50 having not been available to us there is an apparent break in the continuity of the picture.

20.2. Tabulation of Performances :

The figures shown in the Tables 21—24 that appear in the following pages reveal many interesting points :

(*a*) Nearly 47 percent of total number of candidates in I. A. examination offered Mathematics in 1929, as against about 2 to 4 percent of the years 1951-55. Ninety-eight percent offering Mathematics in I. Sc. examination of 1929, went down to 85 percent in 1954, having fallen down further to even 81 percent in some of the intermediate years.

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* Study of some of the points of this Section was begun in 1956 at the instance of late Dr. J. C. Ghosh, the then Vice-Chancellor of the University of Calcutta, India.

TABLE 21 : *Showing the Total Number of Students Appearing at I. A. Examinations of the Calcutta University with Percentages of Students Offering Different Subjects for the Years 1929-1941 and 1951 onwards.**

YEARS :	1954	1953	1952	1951 ...	1941	1940	1939	1938	1937	1936	1935	1934	1933	1932	1931	1930	1929
No. of I. A. Candidates	11,731	9,946	8,849	10,702	9,127	8,463	7,124	6,712	6,267	5,845	5,435	4,913	4,144	3,473	3,626	3,854	3,359
I.A./I.Sc. Ratio	0.92	0.86	0.80	0.86	1.92	2.05	1.94	1.76	1.84	1.60	1.48	1.34	1.12	1.06	1.08	1.10	1.02
Bengali	87.1	85.7	85.7	87.5	90.0	90.1	89.9	88.7	89.4	89.8	89.3	89.1	89.5	89.9	89.8	90.1	84.8
English	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100,0	100.0	100.0	100.0	100.0
Civics	96.9	96.5	97.7	96.9	90.1	86.7	83.2	79.2	67.9	73.0	72.7	65.8	55.9	42.3	32.0	17.8	10.3
Comm. Geogphy.	69.7	72.9	68.9	68.5	11.1	7.4	5.8	5.5	5.1	5.1	3.8	3.0	2.8	3.3	3.0	3.2	3.0
History	42.8	46.8	40.2	37.9	37.7	34.2	33.1	33.2	32.5	30.8	30.4	33.5	36.1	43.2	46.4	50.7	46.6
Comm. Arith. etc.	42.3	40.9	43.2	45.5	8.4	5.6	4.2	3.4	2.8	2.7	2.5	2.0	2.0	2.4	2.5	2.4	1.8
Logic	32.8	34.5	37.7	37.7	71.7	76.0	79.7	80.6	80.7	82.5	83.5	84.8	86.7	86.6	89.4	91.1	91.4
Sanskrit	14.7	15.2	15.0	15.3	40.4	52.8	57.8	57.2	56.0	58.1	60.0	61.7	59.6	61.9	63.8	67.4	66.6
Mathematics	3.8	1.9	2.2	1.9	9.2	12.4	12.6	13.5	14.6	17.3	21.6	22.1	22.0	25.2	28.2	32.1	47.0
Botany	2.2	2.8	2.1	2.5	6.0	6.6	7.7	8.7	8.9	9.2	8.3	9.7	6.2	9.7	10.2	10.9	9.4
Geography	0.4	0.5	0.3	0.5	0.6	0.6	0.4	0.3	0.3	0.5	0.5	0.5	0.8	1.0	0.6	0.6	0.7
Biology	0.1	0.04	0.03	0.04	0.2	0.1	0.06	0.07	—	—	—	—	—	—	—	—	—
Chemistry	—	0.01	0.03	0.02	0.7	0.8	1.2	2.1	3.0	4.1	4.3	5.7	6.9	6.6	7.9	7.7	9.6
Anthropology	—	—	0.01	0.02	0.3	0.4	0.4	0.5	0.03	—	—	—	—	—	—	—	—
Psychology	—	—	—	0.03	0.2	—	—	—	—	—	—	—	—	—	—	—	—
Physics	—	—	—	—	–	0.01	—	–	0.03	0.02	0.1	0.02	0.1	0.03	—	0.03	—
Military Science	–	–	–	–	0.09	0.06	0.2	—	—	—	—	—	–	—	—	—	—
Zoology	—	—	—	—	—	—	0.01	—	—	—	—	0.02	—	—	—	—	—
Physiology	—	—	—	—	—	—	—	0.01	0.02	0.05	0.02	0.02	0.02	0.06	–	–	—

* Source : Calcutta University Reports 1929-1941 and 1951 onwards. Data for the period 1942-50 were not availble.

TABLE 22 : *Showing the Percentages of Passes in Different Subjects in I. A. Examinations of the Calcutta University for Years 1929-1941 and 1951 onwards.**

YEARS :	1954	1953	1952	1951	...	1941	1940	1939	1938	1937	1936	1935	1934	1933	1932	1931	1930	1929
Bengali	83.1	77.1	70.0	54.5		77.7	89.4	91.8	93.5	93.1	94.6	95.6	94.9	90.7	90.1	87.6	87.9	94.8
English	58.6	40.7	35.8	34.9		62.6	70.4	64.5	61.6	58.7	63.6	61.8	64.5	64.3	57.9	55.0	53.8	59.4
Civics	86.6	85.1	81.3	72.6		74.6	78.2	81.1	84.2	92.4	82.6	87.7	83.4	90.3	90.4	87.6	74.0	91.3
Comm. Geogphy.	93.9	91.7	91.9	88.5		92.8	96.0	93.3	88.3	87.9	79.6	91.5	93.0	78.6	81.5	83.1	76.8	77.0
History	86.1	86.5	77.2	74.1		85.4	92.6	92.0	91.4	94.1	94.3	92.3	93.7	86.5	73.1	59.8	65.7	67.5
Logic	77.9	76.5	68.5	45.1		82.3	87.8	80.0	75.5	80.1	81.0	80.5	79.5	87.1	75.8	70.6	71.9	77.0
Comm. Arith. etc.	69.1	68.9	86.1	88.5		62.6	82.3	82.2	81.4	90.0	66.7	72.3	54.6	55.4	46.9	82.2	81.7	66.7
Sanskrit	87.2	61.6	79.5	64.3		87.8	93.9	90.8	89.6	88.1	93.2	96.5	92.5	93.5	87.5	90.7	85.0	90.1
Mathematics	86.7	64.3	79.6	68.4		79.1	79.4	78.3	71.7	84.0	69.8	84.7	69.2	78.9	78.9	71.1	79.8	85.1
Botany	88.9	85.4	79.7	73.2		71.9	81.4	75.7	79.2	76.2	74.4	76.4	78.4	65.7	67.4	69.8	59.6	64.6
Geography	100.0	100.0	92.5	92.8		100.0	100.0	96.2	99.9	100.0	81.4	88.4	66.7	73.5	77.1	57.1	88.0	96.0
Biology	100.0	100.0	100.0	100.0		77.2	100.0	100.0	100.0	—	—	—	—	—	—	—	—	—
Chemistry	—	—	66.7	50.0		71.6	73.2	77.6	78.1	85.9	69.4	65.2	74.1	73.3	74.1	70.1	71.1	79.8
Anthropology	—	—	—	100.0		93.3	87.8	96.5	91.6	100.0	—	—	—	—	—	—	—	—
Psychology	—	—	—	100.0		95.5	—	—	—	—	—	—	—	—	—	—	—	—
Expt. Physics	—	—	—	—		—	100.0	—	—	100.0	100.0	57.1	—	100.0	100.0	—	100.0	—
Military Science	—	—	—	—		75.0	80.0	100.0	—	—	—	—	—	—	—	—	—	—
Zoology	—	—	—	—		—	—	100.0	—	—	—	—	100.0	—	—	—	—	—
Physiology	—	—	—	—		—	—	—	—	—	66.7	100.0	100.0	100.0	100.0	—	--	—

* Source : Calcutta University Annual Reports. Percentage is on the Actual Numbers Sitting for the Examinations.

(*b*) This avoidance of Mathematics by I. A. and I. Sc. candidates have been in the ascending order with a sharp rise in 1941 onwards as the figures indicate.* Unfortunately the data for the period 1942-1949 were not made available to us, as they were not published in the Reports of the Calcutta University for these years. The same trend appears to have gone on upto this day.

(*c*) One other subject in the I. A. examination, the subject Logic, has met the same fate as Mathematics. Ninety-one percent offering Logic in 1929, has come down to thirty-three percent in 1954.

20.3. Analysis and Discussion of Results :

An attempt may be made to explain away this sad state of affairs with Mathematics, by pointing out the fact that the new subjects such as Civics, Commercial Geography, Biology, etc., have been introduced later in I. A. Examination curriculum. But it should be admitted that this explanation is far from satisfactory. Mathematics is a good score-getter and it is an essential subject for Science students. Furthermore the students get the chance of having previous training for long ten years at the High school stage. Therefore, the possible point above to maintain that new subjects are elbowing out Mathematics does not hold ground. In fact the ratios of I. A. to I. Sc. students (Tables 21 and 23) tend to show that approximately 1 : 1 ratio of 1929, is gradually returning to this value having undergone changes in intervening years.

It is observed that inspite of lesser number of candidates taking up Mathematics in Intermediate examination of to-day than of previous years, the percentage of passes among candidates offering Mathematics has remained almost constant for the last twenty-five years. The figures for 1929 and 1954 are 85.1 and 86.7 percent respectively with some fluctuations in between these years. We believe that this somewhat stable percentage of passes does not present at all a hopeful situation especially when manipulation for mechanical raising of number of passes by allowing grace marks is often resorted to. The figures showing the percentage of passes in different subjects for all these years are also given in the Tables 22 and 24.

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* It may be noted in this connection that the character of paper-setting in Compulsory Mathematics underwent a thorough change during the year 1939 and since then the pattern has been more or less alike. We are inclined to observe that the question papers of last ten years particularly lacked the special qualities of having in them appropriate items, which could encourage the students to pay proper attention to the entire area of the subject.

Hence the irresistable conclusion is that owing to defective standard of paper-setting in Mathematics for the School Final examinations, there has been an unwholesome effect on teaching in class-rooms and this has made Matriculates of recent years feel too ill-equipped to take up Mathematics at Intermediate stage. It is this fact which has been brought out in bold relief by our survey of the papers on Mathematics (Comp. & Addl.) of the School Final Examination, 1952. We have already noted that the Question Paper on Compulsory Mathematics for the year enabled even a student of Class VII or Class VIII to secure pass marks and even quite high marks very easily. If a student knew Simplification, Practice, Factorisation, Graph drawing and the Book I of Geometry which are all done in lowers forms, he will be able to secure 38 percent marks atleast, if not more.

It is surprising again to note that the ten percent sample of our survey of a population of about forty thousand candidates would consist of only 253 students offering Additional Mathematics. Only one student out of every sixteen is inclined to offer Additional Mathematics with very little probability of promising results. For, as we have seen, only 16 candidates out of 253 have been able to score more than 70—80 percent marks on the Additional Mathematics paper. It shows there is hardly about 160 students in the whole population of forty thousand candidates who may be taken as to have received adequate grounding for studying higher mathematics in college courses. There is a belief that ten percent of the students are born with mathematical ability. Assuming this to be true the system of education or examination as is obtained here for quite a long period has been able to provide scope for the development of mathematical ability only in 4 cases out of 100, that are supposed to possess real mathematical aptitude, in every thousand Matriculation or School Final student population.

20.4. The Question Papers and the Proficiency Standard for the Students :

That the paper-setters can really guide the students in their study of a subject of the curriculum goes without saying. They have a considerable influence in setting a standard of preparation for the candidates. If the questions representative of the whole syllabus on the subject need be prepared for passing a paper, then the students will certainly devote time to cover the entire course. But if they discover somehow from the question papers of past years that not only a pass, but scores of 50 to 60 percent and even above can also be easily secured by preparing a few topics of the subject then the negligence on the part of even capable students to learn the rest of the topics is inevitable.

As we have noted above the proportion of students offering Mathematics in the I. A. Examination especially, is getting gradually low and that remarkably

TABLE 23 : *Showing the Total Number of Students Appearing at I. Sc. Examinations of the Calcutta University with Percentages of Students Offering Different Subjects for the Years 1929-1941 and 1951 onwards.**

YEARS :	1954	1953	1952	1951 ...	1941	1940	1939	1938	1937	1936	1935	1934	1933	1932	1931	1930	1929
No. of I. Sc. Students	12,756	11,624	11,011	12,396 ...	4,745	4,119	3,669	3,818	3,413	3,650	3,666	3,654	3,703	3,272	3,348	3,488	3,311
I.Sc./I.A. Ratio	1.09	1.17	1.24	1.16	0.52	0.49	0.52	0.57	0.54	0.62	0.67	0.74	0.89	0.94	0.92	0.91	0.99
English	100.0	100.0	100.0	100.0	100.0	100.0	98.8	99.2	98.9	99.4	99.3	99.2	99.4	99.5	99.6	99.8	100.0
Ind. Language	100.0	100.0	100.0	100.0	100.9	100.0	98.8	99.2	98.9	99.4	99.3	99.2	99.4	99.5	99.6	99.8	100.0
Chemistry	99.9	98.6	100.0	100.0	100.0	100.0	98.8	99.2	99.0	99.4	99.3	99.3	99.4	99.5	99.6	99.8	100.0
Physics	99.8	88.7	97.2	95.4	98.5	98.2	96.4	97.5	96.1	97.3	89.1	96.8	92.0	96.1	98.1	97.4	97.6
Mathematics	85.0	84.2	82.1	81.4	94.6	97.0	95.2	93.9	93.3	93.0	84.2	94.0	90.6	94.8	95.8	96.3	98.4
Biology	48.3	49.9	51.9	50.4	11.0	7.2	6.3	5.6	3.1	2.2	0.2	—	—	—	—	—	—
Botany	3.1	3.8	5.0	6.3	22.1	22.2	20.0	22.5	25.5	27.4	25.6	23.9	23.2	25.3	26.3	24.6	21.2
Geography	1.3	1.0	1.6	1.3	—	0.6	0.5	0.4	0.6	0.9	0.6	0.4	0.4	0.4	0.3	0.3	0.4
Geology	0.8	0.8	0.5	0.6	—	—	—	—	—	—	—	—	—	—	—	—	—
Psychology	0.1	0.1	0.1	0.3	0.8	1.4	1.6	1.4	2.4	1.9	1.7	1.5	1.5	0.9	1.1	1.0	1.2
Anthropology	0.09	0.09	0.2	0.2	0.9	1.2	1.3	0.3	—	—	—	—	—	—	—	—	—
French	0.07	0.06	0.08	0.1	—	—	0.2	0.08	0.06	—	—	0.03	0.03	—	—	—	0.03
Zoology	—	0.03	0.08	0.1	1.1	1.8	1.5	1.2	0.7	0.9	0.1	0.1	0.2	—	—	0.03	0.03
Military Science	—	—	—	0.3	0.3	0.1	0.4	—	—	—	—	—	—	—	—	—	—
Exptl. Psychology	—	—	—	—	0.2	—	—	—	—	—	—	—	—	—	—	—	—
Italian	—	—	—	—	—	—	0.05	—	—	—	—	—	—	—	—	—	—

* Source : Calcutta University Reports 1929-1941 and 1951 onwards. In the years 1930-1939, some candidates offered special subjects other than English and Indian Languages.

TABLE 24 : *Showing Percentages of Passes in Different Subjects of the I. Sc. Examinations of Calcutta University for Years 1929-1941 and 1951 onwards.**

YEARS :	1954	1953	1952	1951	…	1941	1940	1939	1938	1937	1936	1935	1934	1933	1932	1931	1930	1929
English	61.8	45.9	40.2	43.6		71.5	72.8	73.3	66.4	59.5	66.7	60.5	65.3	58.8	54.1	61.4	53.6	65.4
Ind. Languages	83.8	78.1	67.5	60.7		85.1	90.3	93.7	93.9	92.5	96.3	95.7	95.3	92.9	87.6	88.8	90.9	99.5
Chemistry	87.1	71.1	68.3	62.7		82.8	79.8	91.4	93.8	90.6	83.1	81.5	82.6	83.2	73.0	75.0	76.7	85.7
Physics	72.0	71.3	71.1	67.7		84.3	86.2	98.8	81.7	80.9	86.4	65.2	77.7	72.7	67.7	67.3	64.1	75.2
Mathematics	69.5	73.3	73.5	66.1		74.6	76.9	76.9	70.0	81.6	74.0	80.9	71.2	79.8	78.9	74.1	76.6	86.1
Biology	81.5	84.9	8.2	78.0		92.4	93.9	96.9	85.4	91.4	92.3	100.0	—	—	—	—	—	—
Botany	78.5	93.1	72.3	51.1		80.4	89.1	89.8	83.2	83.3	81.5	86.1	87.0	80.3	63.1	52.3	42.4	84.1
Geography	87.6	98.2	91.4	77.8		—	100.0	100.0	100.0	100.0	76.4	95.6	83.3	60.0	91.6	81.8	66.6	100.0
Geology	96.2	98.9	100.0	100.0		—	—	—	—	—	—	—	—	—	—	—	—	—
Physiology	100.0	100.0	100.0	100.0		92.3	94.7	100.0	92.3	90.3	75.8	100.0	96.2	82.4	96.6	81.1	85.7	97.4
Anthropology	100.0	90.0	52.6	56.5		85.1	100.0	97.7	97.2	100.0	—	—	—	—	—	—	—	—
French	100.0	100.0	100.0	100.0		—	—	100.0	66.6	100.0	—	—	100.0	100.0	—	—	—	100.0
Zoology	—	100.0	87.5	75.0		70.0	93.1	100.0	89.1	100.0	100.0	80.0	60.0	100.0	—	—	100.0	100.0
Military Science	—	—	—	100.0		53.8	100.0	100.0	—	—	—	—	—	—	—	—	—	—
Exptl. Psychology	—	—	—	—		100.0	—	—	—	—	—	—	—	—	—	—	—	—
Italian	—	—	—	—		—	—	100.0	—	—	—	—	—	—	—	—	—	—

* Source : Calcutta University Annual Reports, 1929-1941 and 1951 onwards. Percentage is on the Actual Numbers Sitting for the Examinations excluding those who offered special subjects and who were absent.

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Calcutta

so from the year 1941, while they are being more and more attracted towards Civics or some Commercial subjects which, as we know, do not require any preliminary study at the secondary stage. But it is a fact which is worth pointing out to students at the Secondary and at the Intermediate stage that the study of present day Economics at an advanced level is practically impossible without a reasonable degree of knowledge of College Mathematics and this is also somewhat true for Psychology and Social Sciences and Commercial subjects. Even if these are appreciated there is hardly any possibility under the existing circumstances of having a good number of students of these latter subjects at colleges and universities to select Mathematics as one of their second optionals.

It is true that Mathematics greatly contributes to the development of a disciplined mind and a logical way of thinking irrespective of the application of mathematics in many vocations. That the past records of Calcutta University examinations included a higher percentage of students offering Mathematics at the Intermediate courses is being confirmed by the figures of the tables presented in this Section. Avoidance of Logic by Intermediate Arts students in their choice of electives is also significant with the figures (Tables 21—24) for the last few decades. Is such gradual negligence of Mathematics or Logic at the Intermediate stages of College education by students of recent years partly responsible for a much talked of marked decline in the all round development of their mental make-up, and the resultant outbalancing of reason by emotion ? It is a pertinent question.

PART IX

THE OBJECTIVES OF TEACHING MATHEMATICS AND THE QUESTION PAPERS UNDER SURVEY

21. THE COMPULSORY MATHEMATICS

21.1. The Mathematical Concepts Introduced in School Final Compulsory Mathematics : Their Knowledge and Application :

The Secondary School Mathematics aims at achieving certain objectives which are to make the students acquainted with a number of mathematical concepts both in their theory and practice. In other words, students are expected to acquire knowledge of these concepts and also to learn the applications of these concepts to concrete problems in real life situations.

Following the method of analysis of L. R. Desai and B. V. Bapat (1958),* a detailed study of the course content of Compulsory Mathematics in all its three branches, Arithmetic, Algebra and Geometry and the question paper on the subject, enables us to find that some twentysix mathematical concepts were possibly intended to be introduced to the School Final Students. They are :

A. CONCEPT OF NUMBERS : (*i*) The decimal base of our number system (*ii*) The significance of symbol.

B. CONCEPT OF GROUPS OF NUMBERS : (*i*) The order of numbers to be added does not affect the sum. (*ii*) Multiplication is another form of addition. (*iii*) The order of factors does not affect the product. (*iv*) The difference of two unequal numbers added to the smaller gives the larger. (*v*) Division is another form of subtraction.

C. CONCEPT OF FRACTIONAL QUANTITIES : (*i*) Whole divided into equal parts. (*ii*) Fraction indicates division. (*iii*) Fraction indicates ratio.

D. CONCEPT OF PERCENTAGE : (*i*) The whole of anything is 100 per cent. (*ii*) Relation between a hundredth fraction and per cent. (*iii*) Comparison can be made in terms of fractions, decimals and per cents. (*iv*) Decimal in hundredth is a per cent.

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*Report of the Seminar on the Teaching of Mathematics in Secondary Schools (1958), by L. R. Desai and B. V. Bapat, published by the All India Council for Secondary Education (Directorate of Extension Programmes for Secondary Education), Ministry of Education, Government of India, New Delhi-2, India.

E. CONCEPT OF AVERAGE : (*i*) Average of two or more numbers is somewhere between the smallest and the largest. (*ii*) Average is merely an indication of generality. (*iii*) If numbers are arranged in order of magnitude, the average is somewhere about the middle number.

F. CONCEPT OF RATIO : (*i*) Ratio is a comparison of two quantities. (*ii*) Ratio is a form of division. (*iii*) Its role in time-distance relationship.

G. CONCEPT OF PROPORTION : (*i*) Proportion is equality of two ratios. (*ii*) The order or sequence of terms of ratios is very important.

H. CONCEPT OF SQUARE ROOT : (*i*) Square root is a special case of division where the divisor and the quotient are equal. (*ii*) Square root is related to squaring and, therefore, can be found by division as well as multiplication of factors.

I. CONCEPT OF DECIMAL QUANTITIES : (*i*) Decimal base beyond the unit's digit. (*ii*) Decimal point has a fixed position and cannot be shifted. Figures or digits change their positions. (*iii*) Decimal is a mere extension of integral number system.

J. CONCEPT OF G. C. M. AND L. C. M. : (*i*) G. C. M. is the greatest common measure or the highest common factor of two or more numbers. (*ii*) Its utility to compare and to find out relationship between two or more numbers. (*iii*) L. C. M. is the least common multiple of two or more numbers. (*iv*) Its utility to compare two or more numbers on the same scale. (*v*) L. C. M. of two or more numbers is a mere extension of their G. C. M.

K. CONCEPT OF MEASUREMENT : (*i*) Distance or perimeter is measurement of one dimension. (*ii*) Area is measurement of two dimensions. (*iii*) Volume is measurement of three dimensions.

L. CONCEPT OF ALGEBRAIC SYMBOL : (*i*) Unlike an arithmetical number, a letter can stand for any number. (*ii*) A generalised number also stands for a particular but unknown quantity. (*iii*) The number system is widened by means of generalised arithmetic. (*iv*) Generalised numbers make algebra a shorthand of arithmetic.

M. CONCEPT OF POSITIVE AND NEGATIVE QUANTITIES : (*i*) Ordinary numbers show amount only, while directed numbers show amount as well as direction. (*ii*) Directed numbers can indicate quantities of opposite values. (*iii*) Directed numbers are signed numbers. (*iv*) Numbers having the same magnitude but different signs have different algebraic values. (*v*) A number which is written without a sign is understood as a positive number. (*vi*) Zero shows a point of origin and is neither positive nor negative. It is the starting point of two opposite magnitudes. (*vii*) In grouping and subgrouping directed numbers, signs are as important as numbers themselves.

N. CONCEPT OF MANIPULATION OF BRACKETS : (*i*) Brackets are a device for grouping a number of quantities and are treated as one. (*ii*) The different types of brackets and their conventional use and sequence. (*iii*) Removal of brackets bothways inside to outside or outside to inside. (*iv*) Introduction of brackets also as above.

O. CONCEPT OF FACTORS : (*i*) Factors of a number are those by which the number is divisible and their product is the number itself. (*ii*) When the number is a prime number, it is divisible by the number itself and the unity.

P. CONCEPT OF EQUATION AND IDENTITY : (*i*) An equation is a symbolic statement showing one expression equal to another. (*ii*) It always bears a sign of equality between the two expressions. (*iii*) Thus the equation is like a balance with equal quantities in two pans. (*iv*) There are always one or more unknowns shown by literal numbers in an algebraic equation. (*v*) The need for keeping the balance of an equation by adding or subtracting, etc. of equal quantities on both sides. (*vi*) There are different types of equations based on the number of index of the literal numbers involved therein.

Q. CONCEPT OF QUANTITIES IN CYCLIC ORDER : (*i*) It is an arrangement of algebraic quantities in a cycle where literal numbers are placed systematically in a clockwise or anticlockwise manner. (*ii*) The quantities involved here are either sums or differences or products or ratios of literal numbers in cyclic order.

R. CONCEPT OF GRAPHICAL REPRESENTATION : (*i*) It is a kind of mathematical language. (*ii*) A graph is a pictorial representation of some relation given in the form of a verbal problem or an equation or a formula. (*iii*) It is a device of saving many laborious computations. (*iv*) A graph may take a linear or a curved form obtained under given conditions. (*v*) The points plotted in different quadrants on a graph paper are signed numbers. (*vi*) Although a graph is drawn from a few points, it is a locus, and shows continuity.

S. CONCEPT OF ALGEBRAIC OPERATIONS IN ARITHMETIC : (*i*) It is a symbolic statement of group of numbers showing one expression equal to another. (*ii*) It always bears a sign of equality between two expressions. (*iii*) There are always two or more unknowns shown by literal numbers in these algebraic equations formed out of a given set of arithmetical numbers.

T. CONCEPTS OF POINT, LINE AND PLANE : (*i*) Plane as a surface of an object. (*ii*) Line as an intersection of two planes. (*iii*) Point as an intersection of two lines. (*iv*) A point serves as a device of fixing a position. (*v*) A line serves as a device of showing a direction or path or length or even movement. (*vi*) A line may either be straight or curved. (*vii*) A line is made up of innumerable points standing very near each other.

U. CONCEPT OF ANGLE : (*i*) Angle is corner. (*ii*) Angle as a device of showing a change in direction. (*iii*) Angle as a device of showing rotational movement. (*iv*) Unit of its measurement. (*v*) Different types of an angle. (*vi*) Angles greater than 360°.

V. CONCEPT OF PARALLEL STRAIGHT LINES : (*i*) As straight lines in the same direction. (*ii*) As straight lines having the same distance between all corresponding points. (*iii*) As straight lines having an angle of 0° between them. (*iv*) If a transversal is drawn, the corresponding angles become equal. (*v*) There may be two or more straight lines parallel to each other.

W. CONCEPT OF CONGRUENCY OF PLANE FIGURES : (*i*) Figures identical in all respects. (*ii*) Figures having all the corresponding parts equal. (*iii*) Congruency as a particular case of similarity. (*iv*) Factors fixing the shape and size of a figure are also the factors for determining the congrueney of figures. (*v*) Congruent traingles are an illustration of the simplest form of congruency.

X. CONCEPT OF COMPARIBILITY OF PLANE FIGURES : (*i*) Figures having the same shape but different size. (*ii*) Figures having the corresponding angles equal. (*iii*) Figures having the cnrresponding sides proportional. (*iv*) Similar figures become congruent when the proportion between the corresponding sides is one.

Y.. CONCEPT OF LOCUS : (*i*) It is path traced by a body moving under given conditions. (*ii*) Locus in geometry is just like a graph in Algebra. (*iii*) For the purpose of tracing any locus there is always something given as fixed and something variable. (*iv*) Any point on a particular locus satisfies the given conditions and any point satisfying the given conditions should be on that locus.

Z. CONCEPT OF DEDUCTION : DIRECT & INDIRECT : (*i*) Various mathematical facts are based on certain fundamental truths, and they require no proof for that. (*ii*) The conclusions of such facts, are deduced, not on the basis of measurement or intuition but on the basis of fundamental truths. (*iii*) A deductive proof always involves certain logical steps for arriving at a conclusion. (*iv*) A certain conventional form of supplying a deduction proof exists in geometry. (*v*) Such proofs exists in other branches of mathematics also.

It was also found that thorough knowledge and comprehension of a particular mathematical concept and a student's power of application of the same are tested through different aspects of a given problem or a question-item. These aspects are ten in number and really belong to each and every mathematical concept ; five of them go to show thoroughness of comprehension and five, the power of application of the knowledge acquired. Not that all the aspects of a particular mathematical concept are to be necessarily present in each and every question-item but any one, any two or all of them should surely be there if the entire area of learning experience based on the syllabus and the question paper is taken into consideration.

21.2 The Aspects of Testing Knowledge of a Mathemetical Concept and its Application :

The student who has acquired knowledge of a certain concept in Mathematics :

Recognises certain terms, principles and concepts. ... (*Aspect No.* 0)

Recognises distinction between closely related terms, principles and concept. ... (*Aspect No.* 1)

Recollects, discriminates and classifies, that is, taxonomises. ... (*Aspect No.* 2)

Comprehends relationships and analogies. ... (*Aspect No.* 3)

Develops logical (deductive and inductive) thinking (Analysis and synthesis), and abstract reasoning.... (*Aspect No.* 4)

On the other hand, the student who has acquired the skill of application of his knowledge of a concept :

Develops computational skill. ... (*Aspect No.* 5)

Draws inferences. ... (*Aspect No.* 6)

Selects appropriate means to accomplish a given purpose. ... (*Aspect No.* 7)

Selects the relevant facts and discards the irrelevant. ... (*Aspect No.* 8)

Applies mathematical principles in life situations. ... (*Aspect No.* 9)

We now present below, in Table 25, our analysis of the question-items in Compulsory Mathematics paper through ten (five+five) aspects mentioned above for judging the knowledge of a concept and the skill of its application.

21.3 Conceptual Analysis of the Question-items in Compulsory Mathematics :

The table (Table 25) shows that two out of the twentysix concepts considered in respect of School Final Mathematics are not represented at all in the question paper. They are : (*i*) Concept of Average, and (*ii*) Concept of Congruency of Plane Figures.

The table also shows that each of the eight important mathematical concepts namely, D, F, G, I, Q, R, S and Y occurs once only in this question paper of thirty-one question-items, although these are the very concepts, (such as, Percentage, Ratio, Proportion, Decimal quantity, Quantities in cyclic order, Graphical Representation of equations, Algebraic operation in Arithmetic Problems and Locus,) which are introduced in the top classes of secondary schools. One should expect more emphasis on these concepts than on others in a question paper on School Final Mathematics.

It may be that a particular question-item involves a particular mathematical concept and its knowledge and application. Even then such a question may not be justified in the question paper of School Final Examination, because there are always gradations of problems which go to test more and more deeply the knowledge of a certain mathematical concept or the skill of the candidate in applying that knowledge in solving more and more complex problems. Hence, in judging a question-item or a question paper, we should never fail to consider the level of intelligence, power of comprehension and application expected of a School Final student. When only formally, a question-item deals with a particular concept and is meant to measure its knowledge and application at a very elementary level, it would not be reasonable to say that objectives of teaching Mathematics at the School Final stage are achieved.

In Arithmetic, as many as four questions, Q. 3(*b*), Q. 3(*c*), Q. 3(*d*), and Q. 4(*a*), refer to the most primary concepts A, B and K only, that is, the concepts of Number, Groups of Numbers, and Measurement.

In Algebra, we also find almost all the questions refer to five concepts only, namely, L, M, N, O and P ; that is, the concepts of Algebraic symbol, positive and negative quantities, manipulation of brackets, factors, equation and identity.

In Geometry, we find most of the questions refer to only two types of concepts, namely, Plane figures, and Angles. Deductive reasoning is a concept which is applied to almost all problems of Geometry, and therefore does not deserve special mention. The concept of congruency of plane figures has not been taken into consideration by the paper-setter.

In fact, all the important mathematical concepts and the different aspects of knowledge and skill with regard to them may find proper representation in a question-paper only when the number of questions is rather large and of the objective or short answer type. Hence the agreed decision of all Seminars and Conferences on Reform of Examinations is that the structure of the question paper of the traditional type must undergo radical change to make the question paper more wide to cover all the important parts of the subject area.

If the objectives of teaching geometry are to be attained, then varieties of geometrical concepts should find place in question-items framed for the purpose of testing both knowledge and skill in respect of those mathematical concepts which are peculiar to geometry and geometry alone. In an earlier section, we pointed out that elementary theorems in geometry given in the question-paper of School Final examination help students without real mathematical ability to get sufficient marks for a simple pass. The wide area in which mathematics is now being used makes it imperative that at the Secondary stage the knowledge and application of mathematical concepts should be co-ordinated with concrete practical problems. Stereotyped questions on book propositions of geometry fail to show whether the objectives of teaching mathematics have been really achieved or not. The remedy lies in the resourcefulness of a paper-setter backed by subject experts, research workers and evaluation technicians.

One very important point regarding the objective of teaching mathematics is to impress upon the students the fact that mathematics is a subject which deals with certain concepts. The value of the subject lies not only in the development of mental discipline and power of systematic reasoning but also in using mathematical knowledge for the solution of concrete problems. Looked at from this point of view, Arithmetic, Algebra, Geometry, Trigonometry and Mensuration are not isolated branches divided in water-tight compartments, but several series of inter-related concepts converging to make a united whole. The Report of the Seminar on the Teaching of Mathematics in Secondary Schools (Desai and Bapat, 1958) has separately grouped the mathematical concepts under three heads, Arithmetic, Algebra and Geometry. In our view mathematical concepts should not be classified that way, because there are concepts which have their places in more than one branch of Mathematics as it is evident from the analysis shown in Table 25.

22. THE ADDITIONAL MATHEMATICS

22.1. The Mathematical Concepts Introduced in Additional Mathematics : Their Knowledge and Application :

The provision for offering any elective subject at the School Final stage gives an opportunity to education authorities for knowing special intellectual inclinations of the students. On the other hand, a student who offers an elective subject gets the first opportunity for specialisation in the subject concerned.

The syllabus of an elective subject should therefore aim at either introducing new concepts of more complex nature in an extended area of the subject matter or should have the objective of acquainting the students with more complex problems involving those concepts which had already been introduced through a compulsory course of studies.

In the previous section, we have studied the syllabus and the question paper on compulsory mathematics to investigate how far knowledge and application of certain mathematical concepts have been taken into consideration.

We now proceed to investigate on the same line the syllabus and the question paper on Additional Mathematics. We have tried to find out what new concepts have been introduced and how concepts already introduced to students are dealt with through newer or more complex problems.

A conceptual analysis of the syllabus and the question paper (see Ante pp. 98-100) shows that some twentythree concepts appear to be involved in teaching the subject and some of these concepts are common with those introduced in the course of studies for Compulsory Mathematics. These common concepts are ten in number, namely,

(A) Approximate Value. (B) Metric system of Measurement. (C) Compound Interest. (D) Percentage of Costing. (E) Groups of Numbers. (F) Square Root. (G) Arithmetic Progression. (H) Laws of Indices. (I) Geometric Progression. (J) Concept of Equations involving Algebraic Fractions. (K) Equation involving Indices. (L) Graphical Representation of Quadratic Equations. (M) Identity. (N) Similarity of Triangles. (O) Ratio in Geometry. (P) Construction of a Circle satisfying several conditions. (Q) Orthocentre of a Circle. (R) Regular plane Figures. (S) Comparability of areas of plane figures. (T) Sexagesimal and Centesimal Measure. (U) Circular or Radian Measure. (V) Trigonometrical Quantities. (W) Problem involving Trigonometrical Quantities.

The listing of the concepts A to W above follows the same line as taken in the case of compulsory mathematics. The concepts are more or less placed in the same order in which the question-items involving these concepts are placed in the question paper. Of these twentythree concepts, we find there are some which are introduced for the first-time through the course of studies of Additional Mathematics. These newly introduced concepts are thirteen in number, namely,

A. CONCEPT OF APPROXIMATE VALUE : (*i*) Approximation according to need. (*ii*) Approximation between certain limits.

B. CONCEPT OF METRIC SYSTEM OF MEASUREMENT : (*i*) Measurement of length and weight in decimal or decamal system. (*ii*) Units of lower values are counted as one-tenth of the immediate higher ones. (*iii*) Units of higher values are counted as ten times the immediate lower one. (*iv*) Its importance in the four fundamental principles of mathematical operations.

C. CONCEPT OF COMPOUND INTEREST : (*i*) Interest for the stipulated period is added to the capital and the sum is taken as the capital for next period. (*ii*) Amount of interest of a later period is greater than that of the former. (*iii*) Interest is expressed as amount of increment per hundred in a stipulated period of time. (*iv*) The increment per unit is a ratio between the amount of interest and hundred.

G. CONCEPT OF ARITHMETIC PROGRESSION : (*i*) It is a series of an ordered set of numbers. (*ii*) Difference between any two consecutive numbers of the set is constant.

I. CONCEPT OF GEOMETRIC PROGRESSION : (*i*) It is a series of an ordered set of numbers. (*ii*) Ratio between any two consecutive numbers of the set is constant.

K. CONCEPT OF EQUATIONS INVOLVING INDICES : (*i*) Indices of numbers or groups of numbers are numbers (positive or negative, integral or fractional) which indicates how many times the numbers or the groups of numbers concerned are being multiplied. (*ii*) It is a simplified and generalised method of multiplication and therefore of addition of the same number or group of numbers. (*iii*) An equation involving indices consists of two expressions involving indices with a sign of equality between them.

L. CONCEPT OF GRAPHICAL REPRESENTATION OF QUADRATIC EQUATIONS : (*i*) It is a pictorial representation of some relation given in the form of a verbal problem involving relations of a quadratic equation.

(*ii*) The points (signed numbers) satisfying the equation and lying in different quadrants make the curve of the equation.

O. CONCEPT OF RATIO IN GEOMETRY : (*i*) It is a comparison of two geometrical qualities and is a form of division. (*iii*) It has a role in line-angle-curve relationship.

Q. CONCEPT OF ORTHOCENTRE OF A CIRCLE : (*i*) The perpendiculars drawn from the vertices of a triangle to the opposite sides are concurrent, and their point of intersection is called orthocentre.

T. CONCEPT OF SEXAGESIMAL AND CENTESIMAL MEASURES : (*i*) Sexagesimal system of measurement is a kind of measurement where angular units are divided and subdivided into one-sixtieth parts. (*ii*) Centesimal system of measurement is a kind of measurement where angular units are divided and subdivided into one-hundredth parts.

U. CONCEPT OF CIRCULAR OR RADIAN MEASURE : (*i*) In circular measure, angle at the centre of a circle is divided into 360 parts and each part is called a Degree. (*ii*) In Radian Measure an angle is expressed as the ratio of arc and radius of a circle.

V. CONCEPT OF TRIGONOMETRICAL QUANTITIES : A trigonometrical quantity is expressed as a ratio of any two sides of a right angled triangle.

W. CONCEPT OF PROBLEMS INVOLVING TRIGONOMETRICAL QUANTITIES : Problems involving height, distance, angle of elevation, etc. are expressed in trigonometrical quantities for convenience of solution.

Of the remaining ten concepts which are common with Compulsory Mathematics, the three concepts viz. (N) Similarity of triangles, (H) Laws of Indices and (P) Construction of a circle satisfying several conditions are in a sense newly introduced. Because in the advanced course of Additional Mathematics, similarity of triangles involves the concept of ratio and proportion and laws of indices includes the concept of involution and evolution of binomial expressions raised to any integral power. Similarly, very simple problems in Geometry like the construction of a circle passing through three points not in a straight line, or touching two intersecting straight lines, are introduced in Compulsory Mathematics classes. But in Additional Mathematics a teacher's business is to introduce more complex conditions which a circle may satisfy, and it has been done in Q.8 *Ei.*, of the question paper under survey.

Earlier in this section we pointed out that knowledge and power of application of a particular concept may have varying degrees of depth and efficiency through more and more complex problems. A good illustration of this is provided by those question-items which involve the common concepts that are already introduced in Compulsory Mathematics.

Of the remaining seven concepts that are common to both the syllabuses of Compulsory and Additional Mathematics, no question-item has been set involving two concepts, namely, concepts of : (R) Regular Plane Figures, and (S) Comparability of areas of different types of plane figure, such as, a square and a rectangle, and so on. Hence, for the purpose of illustrating the wide range of complexity which a particular concept may provide, we have the remaining five concepts, namely, (D) Percentage of costing, (E) Groups of numbers, (F) Square root, (J) Equation, and (M) Identity. Of these five concepts, groups of numbers is a basic concept in Mathematics and does not deserve special treatment.

A comparison of the question-items, Q. 2 *or*, Q. 3 Ei, Q. 3 Ei (*i*), Q. 5 Ei (*i*) and Q. 6 of Compulsory Mathematics Paper and Q. 4(*c*), Q. 2(*c*), Q. 5(*c*), Q. 5(*d*) and Q. 6(*d*) of Additional Mathematics Paper will reveal how the same concept may be introduced through problems which have wide differences in points of difficulty and complexity. The concept of percentage in a problem of Stocks and Shares is far less complex than when it involved in a problem of Compound Interest or Problem of Costing. The concept of Equation introduced in Compulsory Mathematics appears in a more complex garb when a problem is set involving Algebraic Fractions as in Q. 5 Ei (*i*). Similarly, the concept of Identity introducd in Compulsory Mathematics comes in a far more complex form when it is involved in square of a quadrinomial expression as in Q. 6. The concept of square root introduced in Compulsory Mathematics when appears in a square root problem in Algebra, Q. 4 Ei (*i*) Additional Mathematics, becomes far more complex both for comprehension and application.

Thus, introduction of concepts is not enough. Depth of knowledge of a concept and power of application of the same may be achieved by students if the concept is introduced through variety of problems with different degrees of complexity. Now we proceed to make a conceptual analysis of the Syllabus and the Question Paper under survey in the following section.

22.2 Conceptual Analysis of the Question-items in Additional Mathematics :

In the following table (Table 26), the question-items are placed in the first two columns, and the column headings at the top describes the concepts involved in the question paper. As in the case of Compulsory Mathematics, the figures under each concept, corresponding to each question-item go to show what aspects of knowledge and application are tested through a particular question-item. The tabulated figures in Table 26 show that of the twenty-three concepts three have not been taken into consideration by the paper-setter, and they are the concepts of (*i*) Construction of Regular Plane Figures, (*ii*) Comparability of Areas of various Plane Figures, and (*iii*) Circular or Radian Measure.

Of these three again, the first two concepts are in common with Compulsory Mathematics and it is important to notice that the paper-setter of Compulsory Mathematics did not set any question-item involving these concepts. Of course, as we have noted earlier, it is not possible to accommodate all the mathematical concepts in a question paper of three hours, if the questions are not short, large in number, and of the objective type.

It is pleasing to note that in this question paper the distribution of concepts has been rather satisfactory. Moreover, the items have been so framed that the question paper as a whole may be considered to have served the purpose of a good instrument for testing the students' knowledge and power of application of the mathematical concepts concerned. Still, it would have perhaps been better if a single question-item involving the concept of Circular or Radian Measure had been set at least as a discriminating item meant for the very best students.

School Final students offering Additional Mathematics generally intend to go in for higher studies in Science and Technology. Hence, we would suggest that both teaching and examination of this advanced course of Mathematics at the School Final examination should have a strong practical bias. To achieve that objective, students should be taught more and more to tackle concrete problems involving mathematical concepts. It is not enough that they are efficient in abstract mathematical operations.

22.3 Concluding Remarks :

Conceptual analysis of the syllabus of any subject, particularly Mathematics, is a very sound basis on which a paper-setter for a public examination may safely and profitably proceed to make the question-items reasonably distributed over the subject area. Another very important and useful result of this conceptual approach is that not only the paper-setter but also the teacher in a class-room may have full command over the entire process of instruction by either eliminating or laying less emphasis on the elementary and the obvious concepts and by deliberately emphasising on more complex ones so that students may acquire thorough knowledge and power of application thereof in order to enable them to tackle problems set in public examinations with full confidence.

TABLE 2

Exa

Co

Question Item No.	Short description Question-It
	ARITHMETIC
1	Simplification
2 Ei.	Measurement of
Or	Compound Intere
3 Ei.	Percentage Prob
Or	Time & Work
	ALGEBRA
4 Ei.(i)	Square root of In
(ii)	Geometric Progr
Or (i)	Simplification of
(ii)	Problem on G.P.
5 Ei.(i)	Simple Equation
(ii)	Equation of Surd
Or	Graph
6	Identity
	GEOMETRY
7 Ei.	Theorem of Boo
	Rider on above
Or	Theorem of Boo
	Rider on above
8 Ei.	Construction Pr
Or	Theorem on 9 p
	TRIGONOMETRY
9 Ei.(i)	Simplification
(ii)	A Problem
Or(i)	Identity
(ii)	A Problem

PART X

SOME OBSERVATIONS ON SETTING OF QUESTION PAPERS AND ASSESSING OF ANSWER SCRIPTS IN MATHEMATICS

23. THE SETTING OF QUESTION PAPERS

23.1. Paper-setting Work in Mathematics :

Certain features already pointed out make it imperative that there should be some change in outlook so far as setting of papers in general and on mathematics in particular is concerned. The following suggestions may be made for the improvement of the structure of question papers.

(*a*) Random grouping of questions of different grades of difficulty should be avoided at all costs.

(*b*) Introduction of alternatives either between individual questions or between groups to create a labyrinth involving incalculable loss of time of students for the choice of a question or a group of questions in the examination halls must be dispensed with.

(*c*) Questions on Arithmetic, Algebra and Geometry on elementary chapters of the subject which students have finished at the early stage of their Secondary education, namely in Classes VI, VII, or VIII should not ordinarily be set at the School Final examination.

(*d*) Question-items of equal value must be of equal difficulty. Time is undoubtedly the most deciding factor so far as the results of examinees are concerned. Hence utmost care should be taken in setting questions so that factor of time and factor of value, that is allotted mark and difficulty may be coordinated. This is of course the ideal. The more a paper-setter realises this in setting questions, better it is for all concerned.

(*e*) In the balancing of alternatives, we suggest that the Method Questions and the Problem Questions should not be alternative to each other. A certain percentage of both should be compulsory so that a number of alternative approaches to the paper may be reasonably low.

One of the strong points in favour of adopting our suggestions on setting of solitary question-items is that if a paper-setter is not conscious of the difficulty values of the question-items he sets, he may easily avoid the dangers of balancing as alternatives question-items which may really differ widely in their difficulty values. Hence is the justification of our recommendation for setting of more single and compulsory items for question papers of public examinations. If there is grouping of alternatives at all, the types of items in each of the alternative groups should be similar. Question-items of predetermined difficulty values can only help in the situation.

23.2 The Objective, the Short Answer and the Traditional Type of Questions :

Though Mathematics as a subject admits of very little cramming on the part of students, yet it is found that some examinees get good marks in questions on geometrical propositions by sheer cramming. We think theorems of elementary nature should not be set in the School Final examination. Riders involving proper understanding of such elementary theorems should rather be set. In this respect objective type of questions may help a great deal. Some questions of the type listed in the following section may be included in each year's question paper. Similar other questions on Geometry can be suitably set for examination purpose by an expert board of mathematics teachers. Information and instruction about introduction of such type of questions should be issued far ahead of the Examination. Mechanical drilling in Mathematics is very important. In the School Final examination not more than one question carrying at most 10 marks should be set. This may be either in Algebra or in Geometry. Measurement of ability in Arithmetic, Algebra and Geometry may be done by certain traditional type of questions. But real understanding of the subject-matter may be much better tested by setting a group of objective type or short answer type of questions of compulsory nature in the three branches, Arithmetic, Algebra and Geometry. Perhaps time is not yet ripe to introduce purely objective type of questions in public examinations of India. Hence, we think that in the School Final examinations, papers in Mathematics or for the matter of that any other subject a combination of the traditional type and the objective or short answer type of questions should be made. By way of illustration some objective and short answer type of questions in Algebra, Arithmetic and Geometry are given below :

23.3 Some Specimen Questions of the Objective and Short Answer Types in Arithmetic, Algebra and Geometry :

Arithmetic :

1. What are the measurements required for calculating the area of the four walls of a room ?
2. Arrange the following fractional numbers in decreasing order :

   $\frac{1}{2}, \frac{5}{8}, \frac{5}{6}, \frac{3}{4}, \frac{7}{12}$.
3. How can you represent a percentage by a fraction ? or, a fraction in terms of percentage ?

4. Express the following statements in terms of fractions:

   (*a*) Ratio of water and milk in a mixture is 2 : 3.

   (*b*) Some 35 percent of the population of Bengal suffer from malaria.

   (*c*) Some ·025 of the total cost of education is contributed by the Government.

   (*d*) Some ·27 of students of the State are weak in Geography.

5. There are classes of equal roll-strength. In the first, the ratio of boys present and absent is 5 : 2. In the second, the ratio is 7 : 3. In which class there is greater number of boys present?

6. Ratio of the age of A to that of B is 3:2. Ten years hence who shall be senior in age?

7. When L. C. M. of three numbers is divided by their G. C. M. what is the remainder?

8. If L. C. M. and G. C. M. of two numbers is divided by their product what is the remainder?

9. Of the L. C. M. and G. C. M. of two quantities which is greater and why?

10. What are the results when £20 10*s* 2*d* is divided by £10 5*s* 1*d*, by £2, by 2*s*, and by 2*d*, and by·2?

Algebra :

1. What is the distinction between a^2 and $2a$? For what value of a they are equal?

2. How do you know that the product of L. C. M. and G. C. M. of two numbers is equal to the product of these numbers?

3. What is the form of equation representing a straight line (*i*) parallel to x-axis, (*ii*) parallel to y-axis?

4. What is the form of equation representing a straight line which passes through the origin?

5. By what must $x-3$ be multiplied in order to obtain $x^2-7x+12$ as a product?

6. What is the quotient obtained by using $x-3$ as a divisor and $x^2-7x+12$ as a dividend?

7. If the area of a rectangle is represented by $x^2-7x-12$, and the length by $x-3$, what expression will represent the width?

8. (*a*) Solve for n : $n^2-1=0$, (*b*) For what two values of n will $\frac{1}{n}$ be equal to n itself?

9. The fractions $\frac{4a}{2x-y}$ and $\frac{3a}{2y-4x}$ may be added together and the result simplified to form a single fraction with $2(2x-y)$ as denominator. What is the numerator of this fraction?

10. What quantity must be added to the numerators of the fractions $\frac{a}{b}$ and $\frac{c}{d}$ respectively, in order to make their values equal?

Geometry :

1. What is the difference between the internal angle of a regular pentagon and that of a regular hexagon ?

2. What is the locus of vertices of triangles standing on the same base and having equal vertical angles ?

3. When can a right angle be drawn in the segment of a circle ?

4. Under what condition a circle can be drawn through four fixed points ?

5. What do you require to know the area of (i) a triangle (ii) a quadrilateral, (iii) a trapezium ?

6. A parallelogram and a trapezium are drawn on the same base and between the same parallels. Under what condition the area of the former will be greater than that of the latter ?

7. A rhombus and a square have sides of equal length, but they are not equal in area. Why ?

8. Two triangles have equal angles. When are they congruent ?

9. Two triangles are drawn on the same base. The vertical angle of the one is a right angle and that of the other is an obtuse angle. Why is the latter less in area than the former ?

10. If two triangles have their sides parallel when can be they congruent ?

24. THE ASSESSMENT OF ANSWER SCRIPTS

24.1 Some Common Errors of the Examinees :

From a scrutiny of the sampled answer scripts under survey the following common mistakes committed by quite a number of the examinees in writing the answers as also quite a few of the examiners in marking the scripts, have been discovered.

A not infrequent error of the students is to forget writing the roll and other identification numbers on the top sheet of the answer scripts and also to forget writing the serial number of the question items in the margin before answering them. This is perhaps due to lack of organised attempt on the part of the examination administrators to see that the instructions printed on top sheets of answer books are well understood and faithfully followed by the examinees. In West Bengal Board, these instructions are of course given in English. It becomes very often difficult in many answer scripts to find out where a particular answer-item begins, and where it ends. The students often leave the so-called rough work of the solution of a problem in an out of the way place where it is mixed up with much irrelevent scribblings. Another difficulty arises out of a very intricate grouping and interlocking of questions, avoidance of which we have already recommended. For example, Q. 5(*a*), (*b*) or (*c*), (*d*), it may mean one of the two things : The item (*c*) is an alternative to (*b*), or (*a*) and (*b*) are alternative to (*c*) and (*d*). This creates a confusing situation.

24.2 Errors in the Assessment of Answer-Scripts :

One of the common errors of the examiners is leaving answer to questions-item unmarked. Failure to maintain uniformity of assessment of the scripts is perhaps an incurable error. Another common error in totalling scores, which when committed, produces a disasterous effect on the examinees. The circumstances under which the examiners have to work might be somewhat responsible for all such errors on their part. For a candidate who commits an error in leaving rough work of the solution of some problem mixed up with much irrelevent scribbling in an out of the way place, say, in a corner of an opposite page without mentioning the serial number of questions, there is every possibility for an examiner to leave a question-item unmarked. In defence of the examiner, it must be said that he is perfectly right in not accepting such an irresponsible and slipshod writing in assessing the answer-script.

The instructions and directions circulated by authorities to examiners are sometimes so worded that they admit of more than one meaning and significance. This very important factor stands as a great obstacle in bringing about uniformity in the standard of assessment of the answer-scripts by examiners whose number runs into several hundreds in a compulsory subject like Mathematics. The practice of holding an examiners' meeting before examination of answer-scripts aims at solving this difficulty, but the written instructions are often differently interpreted by diflerent examiners and head examiners. Lack of uniformity of assessment produces a very bad effect on scores of candidates as a whole and thus defeats to some extent the very aim of examination, namely, ranking of candidates on the basis of their aggregates. We may note however that remedial measures for such error of the examiners are there in an all out drive for the improvement of their general conditions.

24.3 Some Remedial Measures :

We believe certain mechanical contrivances may go a great way in eliminating some of the common errors which are referred to above.

(*a*) Printed instructions should be given to every candidate that at the top and bottom of every answer-item, double horizontal lines from one end of the page to the other must be given ; penalty of non-compliance being cancellation of the answer altogether. The most probable effect of this will be :

(*i*) Students will not fail to give the serial number of the question in the margin against every answer item.

(*ii*) The possibility of any answer going unmarked by the examiner will automatically be eliminated.

(*iii*) The possibility of wrong totalling will be consequently reduced to a great extent and thus examiners will be safe from penalisation on this account.

(*iv*) Students will avoid scribbling and rough work at different places of the answerscripts to the great convenience of examiners and scrutinizers.

(*b*) A model answer script should be evolved from a threadbare disscussion of paper-setters and examiners in a specially convened meeting. Such model answers should be prepared in respect of every question paper of every subject and copies of the same should be given to the examiners concerned.

(c) Detailed instructions for assessment and the model answers prepared in the examiners' meeting will go a great way in securing uniformity of assessment by eliminating personal factors of examiners, even in the matter of assessing performances in language papers.

What is now done is not enough. Firstly, model answers are not prepared and distributed ; secondly, detailed instructions to secure objectivity of assessment are not printed and circulated amongst the examinees. Mere oral discussions or brief instructions do not serve the purpose.

(d) To reduce the chances of an item of answer being unmarked or double-marked by an examiner, there should be printed on the top sheet of the answer book an oblong frame of a table divided into a number of columns for entering of the serial number of question-items and the marks scored by the students. There should be three rows, the upper row for the student to enter the serial number of the question-item and the middle row for the student again to fill up with a tick mark the question-item that he attempts and the last row for the examiner to enter the score.

In the current practice of grouping and sub-grouping of question-items of different subjects the printing of their serial numbers on the upper row is not possible. But we strongly feel that all question-items should be serially numbered irrespective of groups or subgroups of question-items in a question paper. If this is done, the Board may have the upper row printed and serially numbered, say from 1 to 40, to accommodate the maximum possible numbers of items in a paper, then the students may be spared to fill up the upper row.

25. A PLAN OF ACTION FOR CONSIDERATION :

Statistical analysis of the performances of candidates in public examinations should be conducted every year just after the examination is over, so that loop-holes, pitfalls and defects found out through analysis may be corrected and may be profitably used in conducting the examinations of future years. Such a statistical survey should take into its purview the following very relevant matters connected with the examination :

(1) How far the detailed syllabus on the subject has been taught in class-room.

(2) How far the question paper in the public examination has been a representative one of the syllabus concerned.

(3) What defects there has been in paper-setting, in matter of allotment of marks, in balancing of alternatives, in grouping of questions etc., as have been pointed out in our survey.

(4) How far uniformity in assessing answers has been maintained.

(5) What regional peculiarities have been noticed in performances of candidates of the urban and the rural areas and what peculiarities, if any, have been found between performances of male and female candidates, and regular and private candidates.

(6) What common errors of examinees have been found in the answer-scripts concerned.

(7) What factors have been at work to disturb the uniformity of assessment of answers by examiners and what type of errors have generally been found in the performances of the examinees and in the assessment work of the examiners.

A body of experts should be appointed by the authorities to investigate the ways and means of utilising the findings and the recommendations of such statistical surveys units.

The final conclusions arrived at by this body should be immediately circulated to the heads of all schools and to the would-be paper-setters and examiners of the next year.

We believe that such scientific approach to the problem of examinations will benefit all concerned : namely, authorities, guardians, teachers, and students. Wide publicity of the results of such studies among persons interested in education of the country (in the State), will go a great way in liquidating the causes of troubles among students.

As an outcome of the short survey of the performance of candidates in School Final Examination in different subjects, a tabular record should be prepared and should be maintained for ready reference for the use of paper-setters and examiners of the next year. Such accumulated information of several years may help the authorities in bringing about a wholesome change in the technique of examination and paper-setting which may lead to definite improvement of teaching in schools.

We further suggest in this connection that such tables in the form of statistical abstracts should be sent to the heads of all High schools so that they may also help in creating the field for an overall change in the right direction for the betterment of Secondary Education. It is needless to add that such statistical information if supplied to schools will reveal to the field workers, that is the teachers in class-rooms, startling facts about the performances of their own pupils who are at the present moment thrown into the examination hall like so many lottery tickets, some winning, some losing, owing to unforeseen and unforeseeable factors operating beyond their control.

PART XI

THE EVALUATION CONCEPT IN EDUCATION AND THE BOARD OR UNIVERSITY EXAMINATIONS

26. PROBLEMS OF PUBLIC EXAMINATIONS :

There is a general agreement that the examination system is hardly satisfactory, and that considerably more importance attached to external examination results has been seriously telling on the cause of education in our country. The criticisms levelled against public examinations are :

(*i*) Question papers in public examinations generally measure power of cramming and not that of real understanding. In other words, they lay more stress on acquisition of information rather than on development of thinking.

(*ii*) It is very often found that the language in which questions are framed is vague and ambiguous and thus admits of various interpretations both by the examinees and the examiners.

(*iii*) Year after year, not only do the types of questions in a particular subject repeat themselves, but the self-same questions are found to be set in consecutive years. The result is that guess-work on probable questions pays rich dividend and encourages cramming, thereby defeating the very purpose of examination.

(*iv*) The question papers do not very often take into consideration the area of the prescribed syllabus and the standard of examination concerned.

(*v*) In view of such drawbacks in paper-setting, the practice generally followed by the examining bodies of granting a simple pass, say, on 30 per cent on each subject and 36 on the aggregate clearly means that the value of the 'Pass' is definitely low.

(*vi*) The essay type questions in examinations of some of the subjects do not appear to reveal adequately students' competence. There is little concordance amongst the examiners in their judgment of quality of answers. The administration of a large scale public examination of today thus allows innumerable chance errors to operate, and give scope for questioning the validity of such external public examinations.

One wonders if there is any justification from the social as well as moral view-point for Boards or Universities to continue with such defective devices of measurement of achievements for passing judgement on the real abilities of the students. The utility of the present system of public examinations appears to be doubtful when, for instance, we are to select candidates for certain vocational courses and for general science and arts college classes. 'The results of external (Board or University) examinations are not very dependable'—is the opinion of the admission offices of most of the Science, Engineering and Technological colleges in the country to-day. They have introduced admission tests in certain selected subjects, because they contend that (i) the attainments with the identical degrees or certificates of different Boards or Universities are hardly equal, (ii) the performances of the students in science and technological courses do not correlate so much with the Board or University examination results as they do with their own admission test scores.

Even many of the employing organisations are not infrequently found to draw more upon their own test procedures for selection of personnel than on the examination results of the Board and University examinations of the applicants.

Evidently, it requires serious consideration about a change in the working practice and administration of our public examinations. We have already observed elsewhere that it is only the paper-setting work, which, if properly done, could tone up the whole education and examination system in our country. But any change in the outlook of paper-setting in a subject would naturally call for corresponding changes in the teaching and also learning processes in the subject contents of the curriculum.

It is not however a fact that all our educational troubles are due to these Board and University examinations. With all their defects, these examinations in India have been of value in the past. They are still closely tied to major selection procedures in the country, both by a majority of employers and by a majority of the higher education authorities. Some are of opinion that external examinations are 'an unmixed evil,' evil in their intent and evil in their effect. But there is perhaps a majority opinion about its retention, and it is taken for granted that examinations are 'a necessary evil'.

As the situation stands at present, it is not a question of abolition of the external examinations, but a question of their retention in a suitably altered or modified form. But in which direction should the changes take place and with what speed the changes should be effected are the problems before us. The need for improvement of the system of examinations has been stressed in the Report of the Secondary Education Commission, (1953)[1] and also in the Report of the University Education Commission (1948).[2]

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[1] The Report of the Secondary Education Commission (1953), appointed by the Ministry of Education, Government of India, New Delhi, with Dr. A. Lakshmanaswami Mudaliar as the Chairman of the Commission.

[2] The Report of the University Education Commission (1948), appointed by the Ministry of Education, Government of India, New Delhi, under the Chairmanship of Dr. S. Radhakrishnan.

27. THE EXAMINATION REFORM MOVEMENTS IN INDIA :

With a view to find out how the defects of the present system of examinations can be removed, the All India Council for Secondary Education, Ministry of Education, Government of India, organised and conducted at Bhopal, Madhya Pradesh, a Seminar on Examinations in 1956. The State Boards of Education, responsible for conducting the public examinations at the secondary stage were represented in the seminar and many experts who devoted long to a scientific study of the examination practice took part in it. In a way, specialist knowledge worked hand in hand with administrative experience to find worthwhile approach to examination problems and to produce workable solutions in keeping with the modern concept of education. The seminar worked on certain of the problems like :

(*a*) the problems of maintaning cumulative records of achievements of students in internal examinations and their weightages in the final external examinations ;

(*b*) the problems of guidance of students for diversified courses on the basis of the cumulative performance records of the internal examinations and the problem of preparation of achievement and aptitude tests and the investigation as to how far the performances on them can be used for guidance purposes ;

(*c*) the practical problems of administration of external examinations and setting-up of research units by State Boards for constant appraisal and review of examination procedure and evaluation ;

(*d*) the problems in general of the papers in written examinations ; viz. (*i*) the extent to which the objective type of question-items should be included. (*ii*) the modifications necessary for the existing essay type of questions with a view to minimize the subjectivity of the assessment of answers, (*iii*) the nature of practical examination in science or other craft and technological subjects, and (*iv*) the physical conditions under which the examinations are to be held.

In regard to the problems of cumulative records, recommendation of the Seminar is that, to start with, 20 percent weightage for them should be given in the final external examination, and that every State Board should adopt this common practice for the sake of uniformity of values of certificates on an All-India basis. It recommends special training for teachers to be entrusted with the maintenance of cumulative records. For, if the job is perfectly done, the Seminar holds that external examinations can gradually be dispensed with. The cumulative records will contain detailed data on students' attainments, abilities and interests, collected by the teachers from day to day and from week to week, and that these records will be put to analysis and scrutiny at the monthly meetings of the teachers concerned.

In regard to educational guidance, the Seminar recommends the use of cumulative records and the scores on aptitude and achievement tests. 'Some comprehensive cumulative records suitably maintained should form the basis of an effective and practicable guidance programme, and that the record keeping should start from the beginning of Class VI. It is of course absolutely necessary to supplement this information with scores on aptitude tests like those of U. S. A. Differential Aptitude Tests, adopted and standardized for Indian conditions.' Achievement tests should be constructed and conducted by the teachers for periodic and annual assessment of students. Objective types of test-items should be introduced in public examinations. *Analysis of results of examination papers should be made by examination units of Boards to bring about gradual improvements of present day public examinations.*

In dealing with some of the practical problems of administration of external examinations, the analysis of the Seminar finds a solution in strongly recommending an Examination Research Unit under each Board, because the problem is complex and typical to each individual State Board. A co-ordination of each such Examination Research Unit's work has been envisaged in their recommendation for establishment of a Central Examination Research Unit. They recommended that the All-India Council for Secondary Education should set up a section for co-ordinating the work of State Research Bureaus and also for advising the Central Board on maintenance and improvement of standards. Lastly, on the problem of the general examination systems the Seminar recommends that at both the external and the internal examinations, there should be the following three types of questions : (*A*) Essay type of question-items : (*B*) Pointed questions admitting short answers and (*C*) Purely objective types of questions. This will in their opinion lead (*i*) to reduce subjectivity, (*ii*) to test effectively the students' knowledge of facts and fundamental processes, and (*iii*) to test the ability of students to understand causal relationship, and to organise and express correctly their thought.

They further recommend that the language of the question-items should be unambiguous and expressed in the language of the medium of instructions. The number of question-items should be relatively large and that the allotted marks should consequently be relatively small. This procedure, in their opinion, will lead to a better sampling from the course area. To reduce subjectivity, their recommendation is for a better organisation and improved working of the board of examiners including paper-setters. The public examinations, in particular, should be completed as quickly as possible. No paper should be of more than two and a half hours duration. The Seminar recommends that the proportion in which the different types of questions should be combined in different subjects can be determined after experimentation by various examining bodies and research units. They also recommend that care should be taken to eliminate avoidable inconveniences and discomforts to the examinees by providing more examination centres in the rural areas. In regard to external practical examinations, they recommend that due weight, to the extent of 50 per cent of the total marks assigned to the practical examination, should be given to authenticated sessional work.

There is no doubt that the recommendations of the Bhopal Seminar will lead to healthy improvement in the examination system. The assignment of weights to internal examination results, and the recommended system of internal assessments will tend to reduce the incidence of errors in public examinations. The introduction of objective type or short answer question-items will minimise the subjective element involved in the examinations. Merits of objective tests are that the examiners' independent assessments may tend to agree more than to differ and the examinations as a whole may be made more reliable and may be less costly to administer and the question papers may command a greater subject area.

28. AIMS OF EXAMINATIONS AND OBJECTIVES OF EDUCATION :

It would perhaps take a long time to bring about worthwhile changes in the system of examination ; for it is difficult to bring about a change if that change is not to take full recognition of the relations, which the examinations bear with other aspects of the educational system as a whole. The syllabus, students' motivation in learning, teachers' motivation and teaching methods—all these interrelated aspects are linked with examination in a complex manner. Any attempt to change one aspect without bringing about changes in all others, will tend to disturb the equilibrium of the system. To work out a healthy change, we have to plan in such a manner that the students, the teachers, the guardians, the administrators and the public are brought into the picture to do their best.

An analysis of the situation reveals that mere perfection of examination tools cannot ensure quality in the products of an educational system. A quality conscious industry cannot, by simply focussing attention on the development of measuring machines, obtain quality goods. It has to introduce healthy improvement in the manufacturing process. When the process is sure to produce good results, the question of procurement of a fine measuring instrument comes in, in order to screen quality products for the users, and to discover, defects if any, for further improvement of the finished material. By simply improving the present-day public examinations, it is not possible to get at the heart of the problem. We have to pay attention to the process, the raw material, the operations and the operators. We have to work with the raw materials of students as and when they are brought in to an educational system and as they are processed upto the time of their being sent up for an internal or external examination, for measuring the degree of their achievement. That is, we have to keenly observe the 'in-coming' student material, to watch them through the 'process', and to measure the 'out-goings' in respect of expected behavioural changes brought about by the method of instructions and learning experiences. We have to orient our ideas about education by a clear formulation of its goals, not merely by planning healthy changes in external examinations but also by planning for the betterment of subject contents, teaching methods, and student learning. Much thought has been given to the formulation of objectives of education in a subject or a group of subjects for a course of studies. In fact, the problem of curriculum construction and instructions cannot make any headway unless satisfactory answers are laid down for questions, such as :

(i) What educational purposes should a course seek to attain ?

(ii) What learning experiences are required to be developed to attain these objectives ?

(iii) How the learner should integrate isolated experience with different subjects for the overall attainment of the goal ?

and *(iv)* What examinations or tests should be considered as appropriate for measurement of the effectiveness of the learning experiences ?

Dr. Bloom and others (1956) have put forward certain principles of classifying objectives, goals or purposes of education in general, without making any very particular reference to a specific subject of the curricula of Board or University courses. The educational objectives would mean the explicit formulation of the ways in which students are expected to be changed by the educative process, the ways in which they will change in their thinking, their feeling, and their action. The formulation of the objectives is a matter of conscious choice on the part of teaching staff based on certain data like *(i)* the level of development of the students in the subject, *(ii)* the needs of the students, *(iii)* their interests, *(iv)* the conditions and problems of contemporary life making demands on them and providing opportunities of work and *(v)* the activities the individuals are expected to perform in the society after successfully completing their education.

In a sound education, the teaching methods, the teachers, the student-attitudes, and the methods of examinations should correlate strongly with the purposes or objectives of learning. Purposes of curricular courses, for individual subjects of a course or the course as a whole, of the Boards as also the objectives of the whole of secondary education in the country have to be formulated in detail. For investigating the relationship between and objectives assessment in Secondary Education, a recent Report* of the Ministry of Education on 'Studies on Internal Assessment in Secondary Schools', starts with a list of some fourteen broad objectives, namely : To develop

(1) the ability to understand the spoken and written word ;
(2) the ability to effectively express, orally and in writing ;
(3) skill in intensive and extensive reading ;
(4) the power of critical thinking, logical reasoning and interpretation ;
(5) knowledge and understanding of subject matter ;
(6) the ability to apply knowledge to new, unique and everyday situations ;
(7) adequate motivating factors, interests and an integrated set of values ;
(8) physical fitness and healthy habits ;
(9) the capacity to make decisions regarding one's vocation ;
(10) certain essential skills like constructional, practical, and drawing skills ;
(11) resourcefulness, creativity and initiative ;
(12) desirable attitudes and appreciations ;
(13) mental health ;
(14) desirable personal and social qualities.

The Report observes that the existing system of examinations can measure only the first six objectives in the list and that again in a partial manner, since skills in reading, oral expression, critical thinking and expression are not involved. None of the significant purposes of learning is thus being served by our public examinations, excepting, as it is all too often said, a single purpose of 'acquisition of information' through realisation of these few objectives or their partial derivatives. 'The teaching procedures, the methods of learning used by students, and the use of the present examinations, all lay stress on the detailed and temporary memorisation of facts'—is the reading of foreign and Indian experts in the field. They say that this one objective of acquisition of information for a short period of time, required to get over an examination, is the dominating reality about the present day Indian education and that there is no attempt at realisation of other goals.

Broadly speaking, learning has two objectives : (*i*) acquisition of information (knowledge), and (*ii*) application of knowledge. The training and testing of the memory of students for factual information may have its importance, but some other significant objectives like mental alertness, capaciiy for clear thinking and clear expressions are more important, and our examinations naturally lack techniques of assessment of these aspects of student learnings. The objectives of secondary education that are given above are not certainly exhaustive, nor are they applicable to all subjects of a curriculum. We have to work first for investigating significant and realistic purposes and goals of learning in several different subjects of a Board or University before we proceed to take up plans for bringing about reforms in the methods of examination, methods of teaching, attitudes in the teachers and the students. Because, as we have noted earlier, all these are closely linked to the purposes of learning.

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* 'Studies on Internal Assessment in Secondary Schools'—Directorate of Extension Programmes for Secondary Education, New Delhi (1960), pp. 1 & 2.

29. THE PUBLIC EXAMINATIONS AND THE CONCEPT OF EVALUATION IN EDUCATION

This is why modern educationists have found out that assessment of candidates' performances in a public examination is not the surest way of knowing whether things are in order. It is 'evaluation' of the entire educational process which can provide a true perspective to see whether desirable effects of education are achieved or not. In spite of the fact that the two terms 'assessment' and 'evaluation' have almost the same signification 'evaluation' has acquired a distinct connotation and denotation of its own. It includes assessment but at the same time covers a far wider area. Assessment refers to performances in an examination, the quality of which is expressed in numerical scores. Evaluation, on the other hand, takes into consideration the basic purpose of education itself, all the intermediate stages of educational activities and finally the resulting effect on a student's integrated personality.

Hence it is quite evident that an expert in evaluation engaged in finding out ways and means for examination and education reform, say at the secondary stage, must ask himself the questions such as :

(1) What are the basic aims, objectives and purposes of secondary education ;

(2) What exactly do we expect of a successful candidate coming out of a secondary school ;

(3) What are the specific purposes for selecting a particular subject, Mathematics, History or Geography in the curriculum.

(4) How far has the framer of the syllabus kept in view these basic objectives, not in an implicit fashion but in a clear explicit manner.

(5) How far has the writer of a so called 'approved text book' of a subject kept in view the basic objectives before treating the subject under different topics and sub-topics of the syllabus ;

(6) How has the teacher approached his pupils with his presentation of the subject and what kind of reactions he has received from his pupils ;

(7) How far the reactions satisfy the basic objectives of secondary education itself and the specific purposes laid down for teaching a particular snbject ;

(8) How can a teacher be helped in his work of teaching in class-rooms with a series of test materials both for preparatory purposes and for acquiring newer knowledge and interpretation of facts both known and to be known by his pupils ;

(9) How can an evaluation expert construct test materials for application by teachers so that the various purposes referred to above might be satisfactorily served ;

(10) Lastly, how should the consumer of education, namely, students themselves be put to test and as the 'proof of the pudding is in eating', the effects of their going through the entire education process should be very carefully analysed whether any screw anywhere has gone wrong in the entire education structure.

It must be admitted that in the wider perspective of social demand, the persons responsible for laying down the principles and objectives referred to above should not look upon themselves as men above errors and not fallible in framing educational objectives to be realised by the rising generation. Experience has shown time and again in many advanced countries that after continuing with the legacy of the mistakes of the former generation men have come to their own and have brought about changes impelled by the sheer force of the time spirit.

30. LIMITATIONS OF THE REFORM OF EXAMINATIONS

Emphasis on research in examinations is the result of public criticism to which the present system of examination has been subjected for many years past. Though the system of education as a whole needs thorough re-orientation, yet the ultimate and the most tangible result of education with which the public are concerned being the results in examinations, a reform of the system of examination was considered very urgent.

Without minimising in the least the importance of the reforms in examinations, it must be pointed out that there are certain limitations, which must be realised if the reform is to be really profitable to all concerned.

Examination is an instrument of measurement of education. Reform of Examinations aims at perfecting that instrument ; whereas education is the thing to be measured both qualitatively and quantitatively.

Hence, it is obvious that perfection of the instrument of measurement may not necessarily lead to the perfection of the thing measured. Our real aim is improvement of education for the production of the better type of human materials. So improvement of the system of examination should be subservient to and conditioned by the fundamental objective of education and by some predetermined processes of its administration. It is very essential that these limitations should be properly realised, otherwise over-emphasis on perfecting the instrument may damage the very substance which we like to measure.

A system of education at any stage, secondary or higher, depends upon the activities of six different groups of individuals, namely, (*i*) the makers of the curriculum (*ii*) the framers of the syllabus, (subject specialists) (*iii*) the teachers in class rooms, (*iv*) the students, (*v*) the paper setters and lastly (*vi*) the examiners.

A thorough understanding and full co-operation amongst the six different agencies enumerated above of educational activity is the only way to secure desirable improvement subjected, of course, to the all pervading and supreme condition of social demand.

Examination as an educational activity occupies the last rung of the ladder and hence, by its very nature, it is preconditioned by the other five factors which are responsible for the performances of students presented before an examiner for assessment. Evidently it follows that a yard-stick of measurement used by an examiner and prepared by himself, without the previous knowledge and co-operation of the other five agencies is bound to be arbitrary and is sure to cause discontent and dissatisfaction. Similar must be the case with the activities of any of the other five agencies particularly the framers of the syllabus and the teachers in class-rooms.

If a single expression could be used to describe the cause of the malady of the present system of education—it is possibly *'ignorance of purpose'*. In the first place the real purpose behind the framing of the curriculum is known only to the framers themselves and is not elaborately broad-cast to the teachers and students. The result is that an average teacher is absolutely in the dark and cannot say exactly why so many subjects are there in the curriculum ; why their weightages so differ that one subject covers 250 marks and the other only 50 marks ; how the study of one particular subject contributes to the total growth of the pupil ; what is the good of learning such precious truths that 'the opposite angles of a cyclic quadrilateral are supplementary ; or Asoke was a disciple of Upagupta, a Buddhist monk', and teachers are simply helpless when a pupil asks such inconvenient questions. To make education a purposeful activity, matters such as the utility of study of several subjects in the curriculum, and the relative importance of their study must be clearly and in detail made by the framers of the curriculum to all concerned, namely the other five agencies mentioned above.

Similar is the case with the syllabus. The purpose behind the choice of selected topics of a particular subject must be clearly known to all the parties. A teacher must know the relative importance of the constituent elements in the syllabus. The teacher, the student and the paper setter and the examiner must know the extent of knowledge which the teacher has to impart and the student has to acquire in respect of different items and topics in the syllabus. A concrete example will make the point clear. If a History teacher or a Geography Teacher is asked about syllabus of History and Geography in Classes IX and X, the reply comes like "Sahajahn and Aurungajeb for Class IX, Shivaji, Clive and Waren Hastings for Class X" and "Europe and Africa for Class IX and India for Class X." Such answers are very significant. They show complete ignorance of the purpose behind teaching that subject. The result is cramming and mechanical teaching; the pupil collects information without knowing the principles operating behind them.

If the system of examinations is to be improved, the teachers, the students, the paper setters and the examiners must know clearly and in detail the aims and objectives behind the syllabus, the precise topics that are to be taught, the quality and the quantity of knowledge which is expected of a candidate. Such a framing of the syllabus is in itself a very useful subject of research. Cryptic cataloguing of contents make a syllabus simply unintelligible both to the teacher and to the pupil. Thus the framers of the syllabus have a very heavy responsibility. Otherwise, the teachers, the paper-setters and lastly the examiners will be making all sorts of guess-work and make a mess of the whole thing in the long run. This is exactly what is happening at the present moment.

A paper-setter must be fully aware of the purpose behind the curriculum and the syllabus, he must also be in full knowledge of the state of affairs going on in class-rooms. He must be setting questions, no matter, whether of the traditional or the essay type or the objective type, which must be of such a nature that teachers and students may not be taken by surprise. The phrasing of questions should not create any doubt in the mind of the examinee about what is expected of him.

The marks allotted on a question-item must be so split that the different aspects may be rightly evaluated, at least numerically, by the examiner. Much can be said on the art and science of paper setting in public examinations.

It is only when the other five agencies have done their work well the stage is set for the examiner for proper assessment of goods presented to him. But, once again it must be remembered with all possible emphasis that each of the six agencies of the educational activity mentioned above must work with full knowledge and consent and co-operation of the other five and in this respect the responsibilities of the two last agencies directly connected with the system of examination, namely, the paper setter and the examiner are the greatest, because they have to take full cognition of the activities of the other three, and thus realise their limitations.

To sum up : The assessment of performances in a public examination is not the surest way of knowing student achievements. It is 'evaluation' of the entire educational process which can provide a true perspective to see whether desirable effects of education are achieved or not. All round development of students going through educational process has the chance of being reflected in the cumulative records of students as envisaged by the, Secondary Education Commission, and as recommended by Bhopal Seminar.

While evaluation covers a wide area, examination occupies only a small but important part of it. But examination has to stay. It is not a question of abolition of examination but it is a case of its retention in some improved form. By making a start with the formulation of objectives of all the different subjects of a curriculum, can an evaluation expert find ways and means for examination and education reform.

Analysis of result of examination papers should be made by examination units of Boards or Universities after each annual examination. The results of such yearly analysis can be fruitfully utilised for a healthy improvement of the framing of the syllabus and the setting of the question papers, from the view point of the objectives of teaching and learning different subjects. The framework of the table showing objectives of teaching Mathematics, being only a tentative one for illustrative purposes, has no pretention to be an exhaustive one. Such objective analysis, if conducted on different subjects, will prove helpful and bring the examination refrom in the line with the evaluation movement. In the present survey our endeavour has been to investigate how far changes can be introduced in the existing system of examinations so that the purpose of evaluation could be served in a better manner.

PART XII

SUMMARY AND CONCLUSIONS

31. SUMMARY OF FINDINGS AND OBSERVATIONS

31.1. The Lines of Investigation :

1. SCOPE OF THE SURVEY :

For many years past the system of education in our country, and particularly the system of examinations which dominates the whole field of education, have been the subject of much public criticism. The Education Commissions appointed by the Government of India from time to time unanimously recommended that the existing system of examinations must undergo changes. One of these Commissions, namely, the University Commission (1948) went so far as to declare : "If we are to suggest one single reform in university education, it should be that of examinations." The Secondary Education Commission (1950-51), in no uncertain terms, recommended thorough changes in the structure of examinations. But any attempt at the reform of education and examination system of a country must necessarily be based on research investigation and studies concerning the existing practice. To start with, we took up a statistical survey of the performances of students in the School Final Examinations 1952 of the Board of Secondary Education, West Bengal, the examinations which under the denomination of 'Matriculation Examinations' had earlier been conducted by the University of Calcutta.

2. NATURE OF THE SURVEY :

Secondary Education occupies a pivotal position in the entire educational structure from Primary to Post-Graduate stage, and hence is the selection of the School Final Examination for our study. Mathematics has been taken up first, because examinations in the subject of Mathematics appear to be somewhat objective by nature. In fact, some subjective factors like examiner's bias, etc. do not enter so seriously in the examinations in Mathematics as in those of other subjects. Of Mathematics, and other important subjects of the curriculum, useful informations have been collected e. g., those concerning (i) the syllabus and the curriculum of a subject—what is taught, (ii) the method of teaching in class-rooms—how it is taught, (iii) the structure of question papers—what is examined, and (iv) the method of assessment by examiners—how it is examined. Our aim in the survey has been to explore the possibilities of healthy and wholesome changes in the working of public examinations.

3. COLLECTION AND ANALYSIS OF DATA :

Out of a total number of 36,305 answer scripts in Compulsory Mathematics of the first School Final Examination of the West Bengal Board, a random sample of 3,717 scripts was taken (10.2% sample of the population). The method of stratified sampling was applied to ensure a representative character of the sample, each examination centre being taken as a separate stratum. The question paper under survey is found to be similar in structure and content to those of other years on the subject of Mathematics in the Matriculation and School Final Examinations covering a period from 1940 to 1958. The findings of our study might therefore be valid for all these years surrounding the year 1952. The question paper of this year's examination and the syllabus of the subject for this period are reproduced in pages 7 to 11 of this report.

4. TABULATION OF PERFORMANCES :

The nature of paper-setting in School Final Mathematics has been analysed on the basis of a statistical study of the performances of students in each of the three branches namely, Arithmetic, Algebra and Geometry. Comparison of marks and percentages of failures, passes and non-attempts with various question-items and their alternatives have been made. Grouping of question-items and balancing of alternatives and their respective weightages have been studied. How far the score on one particular question-item reflects the total mathematical ability of the student as measured by the total score on the full paper, has also been investigated. Such analysis involved a study of the relationship of marks in a particualr question-item with the total marks on the full paper.

5. APPROPRIATENESS OF QUESTION-ITEMS :

It may be noted that the appropriateness of a question-item is usually judged by referring to several of its aspects, namely, (*i*) *its power of discrimination*, that is, how far the responses to the question-item may help the examining authorities in ranking the candidates in order of merit or classifying them into several groups of superior and inferior ability ; (*ii*) *its difficulty value*, that is, the value of the question-item in relation to that of the whole paper on the basis of the responses of candidates ; (*iii*) *its suitability* from the view point of the syllabus of the subject for the examination ;

(*iv*) *its reliability*, that is the consistency with which the question-item measures the proficiency of the candidates in the subject ; (*v*) *its validity*, that is, its efficiency to measure the true ability of the candidates in the subject ; (*vi*) *its usability*, from the viewpoint of the concepts covered by the syllabus in both their knowledge and application objectives.

6. DISCRIMINATING POWER :

The discriminating power of a question-item has been studied by defining an index of discrimination in terms of the mean value of item score averages beyond and below the ability level corresponding to different standards of achievement on the item. (See Part III pp. 31-42). The discriminating power and the level of discrimination have a somewhat relative value. They are related to and dependent on the standard of success chosen for consideration. We have shown how a particular question-item may have a number of discriminating powers corresponding to different levels of discrimination arising out of a number of standards of success ; for instance, 30%, 50%, 60% and 80%, corresponding to third, second, first divisions and distinction marks chosen by the examining authorities in West Bengal, have given rise to four levels of discrimination and four discriminating powers of each and every question-item. (See Table 4, p.40)

7. DIFFICULTY VALUE :

The difficulty value of a question-item is one of its important qualities by which students' ability to respond can be determined. Unlike the discriminating power, the difficulty value has no relation to and does not vary with any accepted standard of success on the question-item. It is related to only one factor, namely, the quality of the examinees involved. If they are gifted, the difficulty value of a question-item would be naturally low as a result of the majority of responses being correct. If, on the other hand, the students are of inferior quality, the difficulty value of the same item might be greater because of majority of incorrect responses. If again the group consists of mediocre examinees, the difficulty value would naturally strike a balance between the two extremes. For a question-item of the objective type, the difficulty value is usually estimated by a formula which involves the proportion of incorrect and correct responses on the item. But, if the responses do not admit of classification into correct and incorrect responses, the estimates of difficulty value presents a difficult problem. Usually in all question-items of an achievement test, marks are scored at almost all points between the two extremes between zero and the allotted marks on the item. What should be the standard of correctness and incorrectness to an item ? Obviously, zero cannot be the only figure to represent incorrect responses ; on the other hand, fully correct responses are rarely represented by the highest possible scores, that is, the allotted mark on the item. To make the matter more complex, the examining authorities again consider several different standards of success, as referred to above, from third division to distiction marks.

8. INDEX OF DIFFICULTY VALUE :

Under the circumstances, we have defined difficulty value of a question-item, in terms of the ratio of the average score to the allotted marks on the item. Since an index on the difficulty value should normally reflect the degree of incorrectness of responses to an item, our definition consists in writing one (unity) minus the above ratio of the average score to allotted mark on the item. The determination of the difficulty value of items which are set in alternative pairs present a rather complex problem. The mean score of any of such items may be calculated in six different ways, leading to six different estimates of difficulty values. Hence, we have calculated all the six values of an item, whenever it is found necessary. (See Table 7 page 50).

9. OPTIMUM MARKS :

The determination of optimum marks on the basis of difficulty values of question-item, *vis-a-vis* the marks allotted by the paper-setter presents an interesting study. We have pointed out that there may be 256 alternative choices for a candidate to select question-items covering one hundred marks. The determination of optimum marks on the basis of difficulty values of items is really a new assessment or re-valuation. Judged by this standard, the weightage of every question-item as well as of the three groups of questions to three sections, Arithmetic, Algebra and Geometry of the question paper on Mathematics, may be said to acquire altogether different values. In other words, in respect of difficulty, the question-items may be said to carry two series of values ; one, the marks allotted by the paper-setter and the other, their estimated optimum marks. This has been discussed in Part IV. pp. 51-56 of the study.

10. RELIABILITY, VALIDITY AND STANDARDISATION :

The investigation into the reliability of the question paper has been made by split-half method over the readings of a group of students, the question paper being split up into two halves, of which the allotted marks are equal. The difference between the mean scores and standard deviations of the group for the two halves of the question paper appears to be negligibly small. The estimation of validity is also a tentative one. For the small group of students considered for the study of reliability, the

Test Examination marks were available and these were used as criterion scores for the candidates. We have shown that standardisation of question-items in public examinations is undoubtedly the most desirable thing, but under the circumstances prevailing in our country, it is very difficult to standardise achievement tests particularly because objective types of questions have not yet been introduced in public examination, and because there are wide variety in the ability levels of students and of teachers and in the teaching environments.

11. CONCEPTUAL ANALYSIS OF THE SYLLABUS AND THE QUESTION PAPER :

We have made comparison of the syllabus of Compulsory Mathematics (see p. 9) and the contents of the question paper under survey (see p. 7) to find out how far the question paper covers the subject area prescribed in the syllabus and whether questions have been set on topics not explicitly mentioned in the syllabus. The question paper has also been analysed from the viewpoint of objectives of teaching the subject, which are to make the students acquainted with a number of mathematical concepts, both in theory and practice. Students are expected to acquire knowledge of these concepts and also to learn the applications of these concepts to concrete problems in real life situations. We have found that there are about 26 different mathematical concepts that are introduced through the syllabus of Compulsory Mathematics in the School Final Examination (see Table 25, facing page 118), and shown how the question-items test the students' knowledge and power of application of these concepts.

12. MATHEMATICS AND LANGUAGES :

We have also made a subsidiary investigation into comparative performances in Mathematics and Languages. The languages which we have considered are English and Regional Languages such as, Bengali, Nepali, Hindi, Urdu and Sanskrit. We have prepared the frequency distribution of scores in Mathematics and Languages and calculated their mean scores and standard deviations. Intercorrelations of different subjects of the examination have also been calculated.

13. ADDITIONAL MATHEMATICS :

Along with Compulsory Mathematics, we have also taken into our study 253 examinees who offered advanced course of School Final Mathematics. The 253 candidates are those who out of our bigger sample of 3717 on Compulsory Mathematics offered Additional Mathematics paper. The line of investigation followed is exactly the same as followed in the case of Compulsory Mathematics. Our purpose was to find out how far students who appear to have special aptitude for Mathematics give an account of themselves through their performances to justify their offering Mathematics as an elective subject. Detailed study of performances in Additional Mathematics, and the conceptual analysis of the Question Paper and Syllabus have been made in Sections 19 and 22.

14. MATHEMATICS IN SCHOOLS AND COLLEGES :

A follow-up study was undertaken to find out how far poor performances in Compulsory Mathematics at the School Final stage have their effects on the collegiate education of those who take up Mathematics as one of the elective subjects. Our aim was to see whether defects of standard of teaching and performances have their repercussion on the mathematical ability of college students. For this purpose, we collected data on the number of students, their performances in Mathematics, and the percentage of success and failures at the I. A./I. Sc Examinations of the University of Calcutta during the period 1929-1954. The investigation yielded very useful and interesting results discussed in sections 20.

15. COMMON ERRORS OF EXAMINEES AND EXAMINERS :

Our experiences in handling a large volume of answer scripts and our detailed study of students' performances in response to the question -items, the analysis of question paper itself and the marking of examiners gave us an opportunity for knowing certain errors and draw-backs of paper-setters, examiners and students, on the basis of which we have tried to make helpful suggestions for an all round improvement of examination as an educational activity. Our points have been fully discussed in Section 23 (See pages 125-132) where we have given some specimen questions of the objective type which may be progressively introduced in the School Final Examinations of the Boards in India.

16. EVALUATION AND EXAMINATIONS :

Lastly, we have studied public emaminations in general and the School Final Examination in particular, with special reference to the subject of Compulsory Mathematics from the standpoint of educational evaluation. In this connection, we have made a historical survey of the examination reform movement in India and have made an attempt to analyse the relation between the aims of examinations and objectives of education, and the relation between the public examination and the concepts of evalution.

17. LIMITATIONS OF REFORM OF EXAMINATIONS :

We have closed our study with a Section on limitations of reform of examinations in which we have shown public examinations, as a type of educational activity, are preconditioned by the objectives and contents of the syllabii and the curricula, the method of teaching, the teaching environments and the ability levels of students concerned. We believe the information obtained through statistical analysis will go a great way in bringing about improvement in public examinations conducted by Boards or Universities in India.

31.2. A Summary of Findings and Observations :

1. The Question Paper—inter-locking of question-items—256 different ways of answering the question-paper—balancing of alternatives—easy items fit for lower classes like classes VII and VIII.

The question-paper under survey contains 31 question-items forming 18 groups of which 10 groups consisting of 16 or 17 individual question-items, a candidate for the School Final Examination has got to answer to secure full marks. The question-items have been so grouped and alternatives have been so arranged that a candidate can select these 16 or 17 individual items in as many as 256 different ways.

The grouping of question-items as we pointed out previously is a special feature of the paper. In fact, the whole paper of 31 questions is divided into 18 groups. A queston arises : Why this grouping at all ? If three branches of Mathematics are to be treated separately, then only three groups, one for each of the three branches, viz., Arithmetic, Algebra and Geometry would have been sufficient. But that has not been done. The result is that a candidate may safely avoid any two branches, say Algebra and Geometry to get pass marks if he is confident that he can secure 30 out of 35 in Arithmetic. We think, the ideal grouping would have been to divide the whole paper into three groups with an instruction that a candidate must answer a minimum number of, say six, questions from every group.

It may be argued that the grouping has prevented the candidates from securing high marks or distinction marks (80 or above) and therefore has helped discriminating candidates of real mathematical ability. That this justification of grouping falls through is evident from the statistical analysis of responses to the components of each group of the question-items. The disparity between the number of attempts and the number of successes in respect of components of a group is striking everywhere. It also appears that there is meagre response to certain questions with which students were not acquainted at all in their class-rooms. Whom does such grouping help ? It helps none. It does not help the candidate to secure marks nor does it help the authorities to measure the mathematical ability of candidates. It creates inconvenience and irritation to the examiners as well. It is therefore better for all concerned to dispense with indiscriminate grouping of items in question papers of public examinations.

It also appears that the examination does not so much measure mathematical ability as it puts a premium on ordinary mechanical drilling. The tabulated results (Tables 2 and 3, pp. 14-17) further reveals that the paper enables even a student of class VII or class VIII to secure pass marks and even quite high marks very easily. In fact, some of the topics on which questions are set are done even in lower forms of secondary schools. The result is that the question paper is rather easy and all but very dull candidates have passed the examination, without being prepared upto the standard of class X of the School Final Syllabus. Such defective paper-setting is bound to produce an unwholesome effect on the standard of teaching in class-rooms. The paper is rather cumbrous with inter-locking of questions by way of alternatives and consumes much time of a candidate in the examination hall.

2. *The Syllabus—its defects—its relationship with the question paper.*

A comparison of the question-paper and the syllabus shows that there are some important topics under the syllabus which are not included in the question paper, and that there are in the paper certain question-items on topics which are not explicitly mentioned in the syllabus. While some important topics done in top classes have been left out, questions on a number of topics done in lower classes, have been included in the question paper. In the syllabus, there are topics which are usually done in lower classes and naturally questions are set on them with the result that really important topics of advanced courses which are done in top classes have to be sacrificed by the paper-setter. Thus, both the framer of the syllabus and the paper-setters are responsible for lowering the standard of instruction and examination.

The entire system of public instruction may be looked upon as a series of closely linked educational activities. The syllabus lays down the contents of the courses ; the class-room instruction deals with those contents ; the paper-setting again has got to refer to the contents of the syllabus. But the majority of examiners on a subject of the present day public examinations, while assessing the performances of candidates, do not generally get the chance of judging how far the question paper is representative of the contents of the syllabus, and their assessments as such are likely to be vitiated by factors beyond their control. We feel that the syllabus of any subject should be more descriptive and explicit in character and details of topics of different nature should be stated in the syllabus as far as possible. For making a satisfactory question paper on a subject of a public examination, a detailed and descriptive form of syllabus, which does not appear to have obtained so far, is very essential.

In the syllabus of mathematics there are topics which are usually done in lower forms of schools, and the present practice is to set quite a large number of question-items on them in the School Final Examination. But we strongly recommend setting of questions on topics covered in top classes for it will help raising the standard of instruction in mathematics in schools and colleges. We suggest that the paper on mathematics should only include those topics which are done in classes IX and X only. Lest such change should create confusion, one year's notice previous to the examination may be given to this effect, so that the candidates may not be put into any disadvantage.

The performances on a full paper on Mathematics may be said to measure mathematical ability only when the question paper is fully representative of the area of the syllabus as a whole. In the present question-paper, all aspects of the syllabus do not appear to have received due consideration of the paper-setter. Lack of satisfactory co-ordination between the syllabus and the question paper is likely to tell on the reliability and validity of the measurement of ability in mathematics. The syllabus of any subject at any stage of education particularly at the secondary stage should be framed with certain definite objectives in view. For, the Secondary Education to-day is considered as a self-contained one, and the students are expected to learn certain subjects, in which their knowledge may help them in continuing their studies in any of the humanities, science or technical courses in universities or technical institutes. These points need careful attention of the syllabus framers of the different courses in secondary education.

Considering all these factors, we feel that the syllabus of mathematics has to undergo changes aimed at giving the syllabus a strong practical bias, that is to lay more emphasis on the practical applications of abstract principles of mathematics. Only the important mathematical principles which would help students to follow their mathematical studies at the next higher stage must find place both in the syllabus as well as in the question paper.

3. The performances of candidates—large percentage of passes on easy items—meagre response to the question-items on topics done in higher classes—minimum pass marks.

The bar diagram (p. 18) and the tables (pp. 16, 17) on performances show that 90 per cent students have secured pass marks in the paper, the minimum pass mark being 30 out of 100. Easy question-items on topics done in lower forms have mostly contributed to this high percentage of success. Another significant fact is that there is very poor response to questions which go to measure real mathematical ability. To some question-items, the response is so poor that out of 3717 candidates, less than even 200 attempts are found. It is important to note that these very questions deal with topics done in higher classes of schools.

If the structure of the question paper under survey continues to be used, a candidate may easily secure pass marks either by avoiding two of the three branches of Mathematics or by avoiding altogether what are done in top classes of schools, for, the minimum pass mark in the subject is set at 30 only. It is therefore thought reasonable to have this minimum pass mark of 30 raised to a higher limit, say, 45 out of 100.

4. The Discriminating Powers of question-items—most of the questions discriminate at low levels—the question paper is not a very strong instrument for selecting students of real mathematical ability.

The discriminating powers of 31 question-items have been shown in Table 4 (p. 40). Judged by the power of discrimination, those easy question-items on which almost all have scored full marks are not at all suitable, because they do not discriminate between students of real mathematical ability and others devoid of it. They do not contribute to the efficiency of an achievement test, the principal aim of which is ranking of candidates in order of merit. Again as these question-items are on some elementary theorems or problems of geometry and algebra, and some elementary operations of arithmetic, they are really meant for lower classes of secondary schools. Justifying the setting of such questions in school final examination, it is sometimes argued that they are useful in testing students' thorough acquaintance with the fundamental principles of the subject. In our view, the reason is not sound enough. Granted that knowledge and application of fundamental mathematical concepts should be tested in the school final examination, the choice of concepts and questions or problems thereon should be so made that two principal objectives are fulfilled, namely. (*i*) a student should never be allowed to score marks by unintelligent cramming ; (*ii*) the fundamental concepts which are introduced in higher classes should, on no account, be sacrificed by the paper-setter in favour of very elementary ones. This is exactly what has not been done in the question paper under survey. In short, we mean to say, if a question does not discriminate, it should not find a place in the question paper of a public examination. If, however, elementary concepts of geometry and algebra are to be introduced in a question paper, it must be done in the form of intelligent riders and problems. The present question papers might require a thorough change in their structure, if the paper-setters aim at making the papers highly discriminating ones. It should however be carefully noted that no innovation should be introduced in the matter of setting questions in public examinations without at least one year's prior notice to teachers and students.

5. *The Difficulty Value—questions of unequal difficulty value are set as alternatives—search for questions-items of predetermined difficulty value is necessary —question-items of low difficulty value—allotted and optimum marks of question-items—weightages of different branches of mathematics.*

In order to avoid, as far as possible, the chance factors being called into play, paper-setters should particularly attend to the comparative difficulty values of question-items, which are to form alternative groups in a question paper. The balanced question-items, the types of which have been encountered in the present paper on Mathematics, should always be of at least approximately equal difficulty values. With a view to secure some information which may help the examining authorities (the paper-setters) in their allotment of marks to the question-items proposed to be included in a question-paper, several such studies for each subject should be conducted for a few consecutive years. Pools of question-items of predetermined difficulty values, on different subjects may be collected through a series of such studies and they would prove very useful to both paper-setters and administrators of public examinations.

By a careful examination of the nature of responses to the items of the question paper under survey, we observe that of the 256 alternative choices to the full paper three representative choices (Table 8, p. 54) may be singled out :

Choice I. The Majority Choice consisting of Qs. 1, 2*c*, 2*d*, 3*a*, 3*b*, 4*c*, 5*a*, 5*b*, 6*c*, 6*d*, 7, 8*a*, 8*b*, 9*a*,·9*b*, 10*a* and 10*b* of which the total allotted mark is *100* and the total optimum mark is *89*.

Choice II. The Most Difficult Choice consisting of Qs. 1, 2*a*, 2*b*, 3*c*, 3*d*, 4*a*, 5*c*, 5*d*, 6*a*, 6*b*, 7, 8*c*, 8*d*, 9*c*, 9*d*, 10*a* and 10*b* of which the total allotted mark is *100* but the total optimum mark is *110*.

Choice III. The Most Easy Choice consisting of Qs. 1, 2*c*, 2*d*, 3*a*, 3*b*, 4*c*, 5*a*, 5*b*, 6*c*, 6*d*, 7, 8*a*, 8*b*, 9*a*, 9*b* and 10*c* of which the total allotted mark is *100* but the total optimum mark is *82*.

Estimates of difficulty values or optimum marks or weightages of different branches of a subject depend upon and are calculated from the responses of candidates. These are determined rather through a process of back calculation on the basis of certain statistical assumptions ; because, candidates first responded to the items and then from the data on their responses, the difficulty values or the optimum marks were calculated. The reliability of these findings may accordingly be low, unless they are made sufficiently broad based on the data of more than one year's examination results. Several such studies are therefore considered necessary. They will help us, in the first instance, to obtain reliable estimates of these measures ; and secondly, to cover all types of questions in a subject and pave thereby the way for standardisation of question-items in a public examination in the course of a few years. There is another limitation to these findings of the difficulty values and the optimum marks. All these estimates may not hold good, if and when as a result of general improvement of the standard of both teaching and learning, performances of candidates of superior abilities would come up for consideration.

Though the main aim of a public examination is to rank candidates in order of merit, yet it cannot be denied that one of the aims is to raise the standard of education. If circumstances improve as a result of more efficient teaching and of thorough screening of candidates through admission tests and internal examinations, then perhaps from the responses of properly instructed candidates of real merit, it will never be possible to get high difficulty values of question-items in public examinations, unless the question paper is set to include items inordinately difficult in character. We envisage an all round improvement of public instruction under which the quality of the sampled population of school final candidates will be far better than what it is to-day.

An important result of our studies on difficulty values of question-items on mathematics has been the determination of proper weightages of different branches of the subject. We have found that in the light of estimates of difficulty values of question-items, the proper weightages of arithmetic, algebra and geometry ought to have been 30, 28, and 42 respectively in place of the present weightages 35, 30 and 35 only. A method by which a set of weights for the three branches may be derived for the purpose of obtaining maximum discrimination of candidates has been worked out. The weights so obtained are more or less in agreement with those calculated from the optimum marks of the question-items. The results of such a study based on intercorrelations of scores on the three branches, as well as the correlations of scores on each branch with those on the aggregate has been reported elsewhere.

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* Gayen, A. K. (1956), Jour. Edn. Psy. Baroda, India pp. 244-256 ; also Nanda, P. B. and Dubey, S. D. (1958) *Ibid.* pp. 1-32.

6. The reliability of the questions-items and the reliability of the question paper.

Generally, reliability of a question paper on any subject is the concern of the examination authorities. But the determination of the reliability of each and every question-item is both interesting and useful, because in a question paper like that of mathematics, there are items which are widely different in nature and they also belong to three separate branches of the same subject. So it is worthwhile to determine the reliability of individual question-items.

The data for estimating the discriminating power of individual items (see Part III—pp. 31-42) and the bivariate tables for frequencies of scores on an item and the total score on the paper (see Appendix Tables) can be used for estimating the reliability of individual items of the paper. If however, the total score on the paper is looked upon as criterion score, the item-total correlation coefficient can naturally be regarded as an estimate of the reliability or even the validity of the question-item concerned.

We have not calculated the product-moment correlation, because, in the first place, it is time-consuming and secondly, the frequency distributions of scores on the items are far from normal in most cases. Instead, we have computed bi-serial correlation coefficient for all the items. Several other measures of correlation, like tetrachoric correlation, Yule's coefficient of association and colligation, and Sheppard's coefficient have been obtained for a comparative study. The results are shown in Table 10 (p. 76) in Section 16, which we have also used for the measurement of validity of the question-items.

The reliability of the question paper as a whole, that is, the consistency with which it measures the ability of the candidates in the subject, is our chief concern. To measure the reliability of this question paper, we have adopted the Split-half Method (Kuder-Richardson 1939), which is most convenient and practicable in the situation. The whole question paper is split up into two halves, each half containing question-items of which the mean and standard deviation of scores are almost equal to those of the items of the other half. The application of well-known statistical methods of testing the equality of means, variances, and correlations etc., of two or more samples helped determining a satisfactory partitioning of the question paper. Application is made of the Spearman-Brown formula for double length of tests. Calculated by this method, the Reliability Coefficient of the full question paper is found to be approximately 0.63 only. It should be noted however that for an achievement examination, especially one on Mathematics, a considerably higher value of the reliability coefficient should be expected than what the present paper has shown.

7. *The Validity of the question-items and the validity of the question paper.*

The validity of a test refers to the degree of accuracy with which it measures what it intends to measure. Evidently, a comparison of measures obtained by a given test or instrument with some true or precise measure by the use of a standard (criterion) test or instrument is always necessary, in order to estimate the validity of the test or instrument in question. We have estimated the validity of the question paper by taking the Internal Test Examination results as the criterion.

It is found that the marks secured by the candidates in the Internal Test Examination are mostly lower than their marks in the School Final Examination. This shows that teachers while testing their own candidates to be sent up for the Final examination apply more rigidly the several principles of examination, namely, consideration of the syllabus, the standard of teaching in class rooms, and average intellectual level of their pupils. Hence it is perhaps not unreasonable to take the test examination marks of the candidates as the criterion scores for estimation of the validity of the paper.

The coefficient of correlation ($r=0.57$) representing the measure of validity of the full paper is found to be not sufficiently high for an achievement examination. On the face of it, the measure is thus not a satisfactory one and the reason is not far to seek. The low index of validity may be said to be a symbol of the defect of the question paper as a measuring instrument of the true mathematical ability—a fact which has already been borne out by the analysis of the question paper from other points of view.

Acheivement tests are usually regarded as self-validating in the sense that they are tailored to measure the products of well-defined objectives in training or education, and therefore, they serve as their own criteria. To know the accuracy of measurement in terms of an index of reliability and validity, the only way is the repeated application of the tests with gradual refinement till they can be finally accepted or adopted. We should not forget therefore that strictly speaking, a single figure like that of correlation cannot be said to represent the measure of reliability or validity, of an achievement test.

8. *Standardisation of achivement tests—the methods and the problems of standardization—scope of research :*

Complete standardization of public examinations is neither possible nor desirable. If the aim is to raise the standard of education and examination, then it is quite evident that a standardized set of questions which should be suitable for the entire population of School Final candidates of today is bound to be something below the desirable standard and hence the aim shall not be achieved. So, under the existing circumstances, it is necessary to conduct study and research on the performances of candidates in public examinations for some consecutive years, with the formulated objectives of the examinations in respect of several subjects in view. If in near future, essay type questions cannot be dispensed with, it is better that certain steps are taken to bring about objectivity in questions for public examinations. In the first place, a question should be so worded that a candidate may know at once what is expected of him by way of either information or interpretation or appreciation. In the second place, in respect of each question paper candidates must be clearly informed on what basis and in what proportion objective type and essay type questions will occur ; and thirdly, for the convenience of evaluation by the examiners, the total mark allotted to a question-item should be split into several parts of which each part refers to a particular aspect of the answer, such as correct information or correct spelling or logical presentation or correct grammatical construction in answers to a question-item on language.

It is far more desirable, to bring about conditions which ensure greater objectivity and uniformity both in candidates' performances as well as in examiners' evaluation than to cherish the almost unattainable ambition of standardising question-items on a dozen subjects for a quarter-million candidates. Prior to any attempt at standardisation both the objective type of questions and reoriented essay-type questions should be introduced in internal examinations of schools and colleges and responses of candidates thereto should be analysed. Unless students get trained in responding to certain types of questions by their teachers, it is never possible to get reliable performances from the same candidates when they sit for a public examination.

9. Performances on Mathematics and Languages—comparison of achievements of boys and girls :

For the sake of convenience of comparative study of attainments in compulsory mathematics with those in six papers on languages, namely English—3 Papers, Vernacular—2 Papers and Classical Language—1 Paper, we have presented the frequency distributions of scores in all the seven papers together in a tabular form (Table—11, p. 87). For the sake of convenience of comparison, scores on English Paper III of 50 marks have been doubled and shown on the scale of 0 to 100 as in other papers.

The polygons of the frequency distributions of marks in different subjects have also been shown in Fig. 5 (p. 88). The number of candidates securing pass marks less one, that is 35 or 29 marks as the case may be, and that securing the minimum pass marks will also be found separately exhibited in the Table 11, (p. 87).

Some of the interesting points about the hierarchy of papers and subjects as revealed by this table and the diagrams are as follows : Of all the seven papers, six on languages and one on mathematics, we find that in English Paper II the percentage of failure (58.5) is the highest and in Mathematics, it is (10.4), the lowest. In descending order of difficulty indicated by percentage of failures, the papers may be arranged thus : (1) English-Paper II, (2) English-Paper I, (3) English-Paper III, (4) Sanskrit, (5) Vernacular-Paper II, (6) Vernacular-Paper I, (7) Mathematics Compulsory.

In Tables 13 and 14 (pp. 92, 94) comparative fugures are given to show the quality of performances of the four categories of candidates. In general, girls have done better than boys. Regular girls score about 6 marks more in average than regular boys, except in English-III, where this figure is 2, and in Compulsory Mathematics, where it is 3.6. The Tables show that regular girls have done better than regular boys in respect of all the seven papers. Better performance of private girls is also observed in respect of all the papers except in English-III. It may be pointed out that as there are only 33 private girl candidates, these observations may not be so reliable. Regular boys score better marks than private boys in all Language papers and in Compulsory Mathematics. The average scores of regular girls are 5 to 10 marks more than those of private girls in all the papers.

***10.** Additional Mathematics in Schools and Mathematics in Colleges—the syllabus and the question paper—mathematical education at the collegiate stage—mathematical proficiency of students.*

Many of the characteristics of the question-paper on Additional Mathematics are found to be similar to those of Compulsory Mathematics paper which we have already noticed. For example, the same practice of balancing of incompatible alternatives and similar bunching together and interlocking of the question-items are found to have been followed here. Regardless of difficulty values, question-items have been set as alternatives, so much so that in some cases the very purpose of the examination appears to have been defeated by the question-items concerned. Mere success in the School Final examination does not mean a good ground-work in the fundamental mathematical principles and their applications. Inspite of lesser number of candidates taking up Mathematics in Intermediate examination of to-day than of previous years, the percentage of passes among candidates offering Mathematics has remained almost constant for the last twentyfive years.

It is true that Mathematics greatly contributes to the development of a disciplined mind and a logical way of thinking irrespective of the application of mathematics in many vocations. That the past records of Calcutta University examinations included a higher percentage of students offering Mathematics at the Intermediate courses is being confirmed by the figures presented in the Tables 21 & 22 (pp. 106-107, 110-111). Avoidance of Logic by Intermediate Arts students in their choice of electives is also significant as shown by the figures (Tables 21-24, p. 109) for the last few decades. Is such gradual negligence of Mathematics or Logic at the Intermediate stage of college education by students of recent years partly responsible for a marked decline in the all-round development of their mental make-up, and the resultant out-balancing of emotion over reason ? It is a pertinent question.

11. The teaching objectives of Mathematics and the question papers under investigation—conceptual analysis of the question-items in compulsory and additional mathematics :

One very important point regarding the objective of teaching mathematics is to impress upon the students the fact that the subject deals with certain concepts and their value lies not only in the development of mental discipline and power of systematic reasoning but also in the solution of concrete problems. A detailed study of the course content (syllabus) of compulsory mathematics in all its three branches, arithmetic, algebra and geometry and the question paper on the subject, has been made to show that some twenty-six mathematical concepts were possibly intended to be introduced to the School Final students. It has also been shown that the knowledge of a particular concept and the power of application are tested through different aspects of a question-item. There are ten such aspects and they belong to each and every concept ; five of them go to show thoroughness of comprehension and five, the power of application of the acquired knowledge. Table 25 (p. 118/119) shows the conceptual analysis of question items in Compulsory Mathematics. All the important mathematical concepts and the different aspects of knowledge and skill with regard to them may find proper representation in a question-paper only when the questions are large in number and are of objective or short answer types. The agreed decision of all Seminars and Conferences on Reform of Examinations is that the structure of the question paper of the traditional type must undergo radical change to make it more wide to cover all the important parts of the subject area. A conceptual analysis (Table 26, p. 124/126) of the syllabus and the question paper on Additional Mathematics (pp. 98-100) shows that there are some twentythree concepts and a few of these are common with those introduced in Compulsory Mathematics.

Conceptual analysis of any subject is a very sound basis on which the framers of the syllabus, the text book writers and the paper-setters may safely proceed to write the text books for class rooms and to make the question-items for public examinations conform with all the important areas of the subjects. Another very important and useful result of this conceptual approach is that the teachers also may gain full command over the entire process of instruction. By this approach they can eliminate or lay less emphasis on the elementary and the obvious concepts and can deliberately emphasise on more complex ones, and the students can acquire a thorough knowledge and power of application thereof, in order to be able to tackle problems set in public examinations with full confidence.

12. Some common errors of the examinees and the examiners and certain remedial measures :

From a scrutiny of the answer scripts under survey, some common mistakes of examinees and of examiners have been noted : A common error of examinees is to forget writing the serial numbers of the question-items in the margins of answer books. The students have often been found to leave the so-called rough work of the solution of a problem in an out of the way place where it is mixed up with much irrelevent scribblings. Another difficulty arises out of a very intricate grouping and interlocking of questions, avoidance of which we have already recommended.

Examiners are at times liable to errors of 'leaving answers unmarked,' 'wrong totalling' and 'non-uniformity of marking'. But these examiner errors are mostly due to careless and slipshod presentations of answers by examinees and partly due to the fact that the instructions and directions circulated by authorities to examiners are sometimes so worded that they admit of more than one meaning and interpretation. This very important factor stands as a great obstacle in bringing about uniformity in the standard of assessment of the answer-scripts by examiners who are usually large in number these days. Besides, each and every examiner has to examine a large number of papers within a short time, which also disturbs sound discretion and right assessment.

The practice of holding an examiners' meeting before examination of answer-scripts aims at solving many of these difficulties, but the written instructions are often differently interpreted by different examiners and even by their different head-examiners of the papers. Lack of uniformity of assessment produces a very bad effect on the marks of candidates as a whole and thus defeats to a considerable extent the very aim of examination, namely, ranking of candidates on the basis of their aggregates. Remedial measures of such examiner and examinee errors must be found out in an all-out drive for the improvement of the system of education and examination in all its stages and in all its aspects. To reduce the chances of an item of answer being unmarked or double-marked by an examiner, there should be printed on the top sheet of the answer book an oblong tabular frame divided into a number of columns for entering the serial number of question-items and the marks scored by the students. There should be three rows ; in the upper row serial number of question-items and sub-items should be printed ; in the middle row examinees should be asked to tick-mark those which they have answered ; in the lower row the examiners will be required to enter the scores on the answer-items.

The 'Bye-Laws for the Guidance of Candidates', printed at the back of admit cards in very small types, and the set of ten 'Instructions to Candidates' on the printed top sheets of answer books for the School Final Examination of the Board of West Bengal, do not, it appears, produce any effect, because the candidates neither find time nor care to read and understand these valuable directions to which their attention should be specifically drawn long before they sit for the examination. We suggest that copies of these 'bye-laws' and 'instructions' should be sent to every school, so that arrangements may be made to explain to the students their meaning and importance. All internal examinations should be so rigidly conducted according to such rules that for untidy, careless and slip-shod presentation of answers, an examinee should be warned or penalised if necessary and marks should be deducted for their illegible or bad hand-writing. All these will automatically tend to reduce the common errors of examinees. Also in many answer-scripts of the Board Examinations, it is very often difficult to find out where a particular answer-item begins and where it ends. As a remedial measure, a rule that 'the candidates should start a new question on a fresh page and all sub-divisions of a question should as far as possible be answered consecutively' might be introduced.

13. Discriminating Powers of Different Subjects in the School Final Examinations of 1952 and 1957.

One of our investigations was to find out whether the School Final Examination of 1952 and 1957 indicated any change in the nature of performances of the two population of students. It may be noted that the syllabus and the structure of questions-papers in the examinations of these two years were practically the same and the difference lay only between the abilities of the two groups of candidates. Inter-correlations of the results of nine papers, three on English, two on Bengali, one each on History, Geography, Sanskrit and Mathematics, for the two years, given in Appendix-C, show that there has been very little difference in the relationship of the papers at the interval of these five years. Another interesting finding is this : For the year 1952, an aggregate score obtained by taking 100 per cent marks of English—II, 95 per cent each of Bengali—I and II, 90 per cent of English—I, 77 per cent of History, 76 per cent of Classical Language, 63 per cent of English—III, 55 per cent of Geography and 52 per cent of Mathematics would have been more reliable and sensitive a discriminator of candidates than the traditional total of all papers on the basis of which students are ranked in order of merit. For the year 1957, the figures for such weights on these papers are found to be

100, 97, 97, 93, 86, 82, 78, 65 and 62 respectively. Thus for both the years, the relative importance of the nine papers remained the same. The figures for Mathematics stand lowest in the heirarchy of papers in respect of their powers of discrimination. A paper by Gayen and Mathur 'On the Best Composite of Scores of Different Papers of a Public Examination' which is soon to appear in print, reports a study on these and other related points.

14. *Public Examinations and 'Evaluation' of Education.*

The assessment of performances in a public examination is not the surest way of judging student achievements. It is 'evaluation' of the entire educational process which can provide a true perspective to see whether desirable effects of education are achieved or not. All-round development of students going through educational process has the chance of being reflected in cumulative records of students as envisaged by the Commissions and Committees of recent years on reform of examinations in India.

As has been noted, evaluation stands for overall appraisal of educational outcomes. It involves the identification and formulation of major objectives of a curriculum, their definitions in terms of pupil behaviour and the construction of valid and reliable instruments for assessing the specified effects. External examinations give only a limited number of testing opportunities, whereas evaluation being spread over the entire period of the student learning, provides more reliable results than the single external examination.

Thus while evaluation covers a wide area, examinations (internal or external) occupy only a small but important part of it and the examinations have to stay. It is not a question of abolition of examinations but it is a case of their retention in some modified or improved form. By making a start with the formulation of objectives of all the different subjects of a curriculum, an evaluation expert can find ways and means for examination and education reform. In addition to achievement tests, the tools of evaluation are intelligence tests, and even aptitude, personality and character tests, and also teachers' observations, both in controlled and uncontrolled situations.

15. *Role of Research in Reform of Examinations.*

An examination, as an educational activity, occupies the last rung of the ladder and hence, by its very nature, it is preconditioned by : (1) the makers of curriculum, (2) the framers of the syllabus, (3) the teachers in class-rooms, (4) the students and (5) the paper-setters. A thorough understanding and full cooperation among these different agencies is the only way to secure the desirable improvement in the internal or external examinations. Any change in the system of examinations has to take full recognition of all the complex relations which the examinations bear with other aspects of the educational process, such as the syllabus, students' motivation in learning, teachers' motivation and teaching methods. Mere perfection in the examination technique will not ensure the improvement of an educational system. Examinations should be subservient to and conditioned by the fundamental objectives of education and by well-planned processes of administration.

The malady in the present system of education is possibly due to ignorance of purpose— the purpose behind the framing of a curriculum nobody knows, neither the students nor the teachers. Similar situation prevails with the choice of selected topics on a particular subject. If the system of examination is to be improved, the teachers, the students, the paper-setters and the examiners must know clearly and in detail the aims and objects behind the syllabus, the precise topics that are to be taught, the quality and the quantity of knowledge which is expected of a candidate.

The results of yearly analysis of examination results can be fruitfully utilised for a healthy improvement of the framing of the syllabus and the setting of the question papers, from the view point of the objectives of teaching and learning. Herein lies the importance of the role of research.

32. SUGGESTIONS AND CONCLUSIONS :

1. The problem areas in the present system of education and examination have drawn serious attention of the people mainly because of a large number of failures these days in the public examinations. The teaching methods in classrooms, the objectives of education and the purposes of examination do not appear to be coordinated factors in our educational system. The effect of this lack of coordination has further aggravated the lack of uniformity in abilities of students and the teaching personnel. Other factors which largely contribute to this unhappy state of affairs are cryptic syllabus in bare outlines which admit of different interpretations, defective form of question-papers that are used in the public examinations and lastly, standard of assessment of students' performances by a large number of examiners which is far from uniform.

2. In order to bring about healthy reform in the existing system of public examinations, our suggestions are that all the aspects of the examination as an educational activity should be thoroughly studied and on each and every one of them some concrete inprovement should be made. For all practical purposes, improvement in the system of examination means improvement of the syllabus, the question paper, the method of assessment and the administration of examinations.

3. Notwithstanding anything that may be decided upon for inclusion in the course content of a public examination in any subject, the syllabus must have specification and detailed description of things to be done by teachers

and students in class-rooms. Not only teachers and students but also paper-setters and examiners must clearly understand how much (quantity) and how thoroughly (quality) an examinee is expected to know his or her subjects. Another point which deserves special attention is that topics in any subject should be graded in the syllabii for classes from the lowest to the highest in such a manner that repetition and overlapping may not cause waste of time and energy.

4. The syllabus should be framed with a view to fulfil the objectives in respect of three categories of students, viz., those who shall go in for higher education, those who shall join some technical course after School Final, and those who shall complete their education at the School Final stage. The college entrants should have some advanced courses in the subject with which the common run of students should not be burdened.

5. The improved syllabus as envisaged above can be effective and may be profitably used only through standardisation of text books. To prepare standard text-books, joint and coordinated efforts of teachers, subject specialists and research workers are necessary. Every Board or University should take an initiative in this direction and maintain a permanent Writing Unit, whose job will be to produce text-books by collecting and classifying materials from all the best available literatures. The text books when prepared should be periodically revised to accommodate new trends and developments and fresh information.

6. Realising the importance of the problem of text books, the Ministry of Education, Government of India, established sometime ago a Central Bureau of Text Book Research at Delhi. A workshop was organised by the Ministry at Srinagar in 1955, in order to formulate a plan for the solutions of text book problems in the country, with the help of a number of text book writers, illustrators, foreign experts, and educational administrators. The Bureau has before it a twofold objective : the first, a short-term one, namely, selection of the best books for the pupils from amongst the books available at the present moment ; and the second, a long term one, which aims at conducting research work for improving the quality of text books in future.

7. The Bureau has since published several brochures on factual survey of text book selection procedures and of existing practices in text book production in different States of India and in several advanced countries of the world. These monographs are meant for acquainting the authors and publishers with the standard the preparation of text books should attain. They also aim at helping the education authorities to formulate policies and execute schemes for production of better text books in future. In some of the brochures, the Bureau has laid down certain criteria and has given designs of score cards to be used for evaluating text books, and methods of analysis of

materials collected from text books for Primary Schools. The Bureau has also started work in connection with the text books of Secondary Schools and some progress has been made with regard to syllabii and books on Physics and Social Sciences. Considering the vast student population and the number of subjects taught at the Primary, Sccondary and Higher Education stages, it may be said that only the fringe of the problem has been touched and much is yet to be done.

8. Besides, the structure of the question paper should undergo radical changes. The question paper in a public examination should touch all important points of the syllabus as far as practicable. Interlocking of questions and balancing of alternatives should not generally go together. The language of questions should never admit of more than one interpretation and the nature of question-items must have been known beforehand by teachers and students while working in class-rooms.

9. Both intelligent guess-work and unintelligent cramming should not be allowed to help a candidate in scoring marks on a question-item. Instead of present essay type questions which are set in public examinations, gradual introduction of short answer and objective type questions should be made.

10. Reliability, Validity and Discriminating Power of questions set in public examinations must be ascertained by setting up a research unit in every Board and University. The work of such a unit should be to study the correlation of the syllabus, the question paper and the performances of candidates ; and consequently to find out the defects of paper-setting and the framing of the syllabus, and loopholes of teaching in class-rooms. Unless such studies are continued for several consecutive years in respect of any or all public examinations, satisfactory results can never be achieved.

11. In the present system of education, the assessment of students' theoretical and practical knowledge in a subject from their performances on a three-hour question-paper is very often questionable, because there are several factors which can influence students' normal performances in the examination hall. The Secondary Education Commission (1952) and the Bhopal Seminar on Examinations (1956) strongly recommended in favour of taking internal examination results of the students into consideration for the determination of their ability in a subject.

12. External examination is inadequate as one single instrument of evaluation of pupil's all-round development. It provides only a limited number of testing opportunities. Internal assessment, as a corrective to this drawback, provides a large number of testing opportunities. Internal assessment is spread over the entire period of the pupil's learning. It is likely to give more reliable results than the single external examination. It is the only appropriate means

of evaluating practical skills and abilities which can be tested in every day situations rather than paper and pencil tests. Even in testing certain acheivements such as ability to apply knowledge in new situations, internal examinations serve better than external examinations, as the former gives enough scope to present a variety of such situations to the pupils more frequently and in a natural setting. Many aspects of personality traits such as character, sense of values, and power of appreciation which cannot be conveniently tested through the external examinations are amenable to internal evaluation.

13. The most essential point about the assessment in public examinations is uniformity of judgement. This uniformity is disturbed owing to the following factors : The language of a question-item is such that different examiners have the chance of taking different views about the right type of answer expected of a candidate ; the paper-setter often allots a round mark on a question-item which itself has two or three aspects, on each of which a student is expected to write down his views. Because the round mark on the item is not split into as many parts as there are aspects, examiners' assessments can hardly be uniform. In the meeting of examiners and paper-setters which are held just after the examination, threadbare discussion is not often done about the grades of answers which may be expected of a candidate. By grades, we mean the basis on which ranking of candidates on each item and on every aspect of a particular question-item, if and when necessary, is to be done.

14. The above mentioned factors go to disturb the uniformity of assessment to an alarming degree when both the candidates and the examiners are fairly large in number. To bring about uniformity of assessment, under the existing circumstances, we suggest as follows : The language of the question should be clear and unambiguous and pointed as far as practicable ; there should be gradual introduction of short answer and objective type questions ; the paper-setter should split the allotted mark on an item into as many parts as the number of aspects of the question which he wants the candidates to write.

15. In the examiners' meetings, the model answers to all the question-items of the paper, prepared beforehand by paper-setters, head-examiners and moderators, should be discussed threadbare, and detailed directions should be prepared for the perusal of examiners. In these directions, how different aspects of an answer to a question-item should be assessed and graded must be clearly shown, just in the nature of an objective chart, so that all that is humanly possible to bring about uniformity of judgement of examiners is not left undone. There should be minimum scope for an examiner to exercise his or her own discretion in the assessment of performances on any of the question-items of a paper. A copy of the proceedings of such meetings should always be sent to every Headmaster or Principal for the guidance of teachers and students.

16. The standard of a public examination as a whole or the standard of examination in any subject varies from year to year. For the same year again, the examination may show considerable variation in standards, so far as its different subjects or papers are concerned. By variation of standard, we mean the difference between difficulty values of questions of one year or subject and those of questions of any other year or subject of the examination. Suppose in an examination all papers carry 100 marks each. If in one paper, a score of 30 cuts down 25 per cent of the students, a score of 60, 80 per cent and a score of 90, 100 per cent of the students in the examination, and if in other papers also we find this identical type of distribution in the different score ranges, then we may say that there is no variation of standard of examination in different subjects. And if such equivalence of score distributions in different subjects is not obtained, it is not justified to pass out the candidates and grade them in order of merit on the basis of a "Simple Total" of the scores in different subjects of an examination.

17. An Analysis of School Final Examination Marks in West Bengal (Gayen and Mathur, 1960) shows that a score of 30 per 100 in Bengali cuts down 20 per cent of students and that 15 per 100 in English, 21 in History, 15 in Geography, 21 in Sanskrit and only 13 in Mathematics also cut down the same 20 per cent of students. The interpretation is that the distributions of scores in different subjects are not equivalent ; because a score of 30 out of 100 in Bengali is equivalent to a score of 15 out of 100 in English, 21 out of 100 in History, 15 out of 100 in Geography, 21 out of 100 in Sanskrit and only 13 out of 100 in Mathematics. So that we are not justified in taking the 'Simple Total' of the raw scores of students for ranking them in order of merit without considering the relative weights of raw scores in different subjects. A student may have scored relatively high marks in all the difficult papers but not as high in some easy papers and so his grand total might rank him down, if due weight is not given to his achievements in difficult subjects.

18. An important study of Mahalanobis and Chakravarti (1934) on examination marks of S. L. C. Examination, 1919, in Uttar Pradesh, points out differences of standards in the different subjects of the examination and calculates equivalent pass-marks in different subjects taking English distribution as standard base. It defines the standard of examination in two subjects to be equal when the distributions of marks in the subjects are statistically identical. In cases of examinations where equivalence of standards of different papers is not obtained, there is a recommendation for taking totals of converted equivalent scores instead of the totals of usual raw scores of students for comparison and gradation of their performances. Hussain (1951) also suggests standardisation of raw scores and calculation of equivalent scores for students appearing in public examinations.

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[22] Maths. Report : Gayen & Nanda : 1958.

19. The marks in all the different subjects of an examination are equivalent when, as we know, on the assumption of normality of the distributions, they show equality of their means and variances. But, as normality of marks is rarely obtained, Bose and Chowdhury (1955) suggest calculation of equivalent scores using suitable frequency curves. A study of Gayen and Mathur (1961) gives certain approximation and it appears to work well and avoid lengthy calculations, particularly in cases of moderately non-normal distributions. It may not be possible to convert the raw scores of all students, but in deciding the top few positions that are announced in public, a Board or a University should take into consideration the equivalent scores of as many 'simple total' top students as might be required.

20. The minimum mark for a simple pass in any subject seems to be traditionally fixed. We believe time has come to reconsider the issue. We have already noted that the difficulty value of a question-item or a question paper in an examination rises or falls according as the ability level of examinees involved is low or high. The difficulty value of a test and the ability of examinees to answer it bear a sort of inverse relation to each other. If the student-groups do not undergo change from year to year in respect of their abilities and attainments (as it can reasonably be assumed under stable economic and educational conditions of a society) then question papers of uniform nature and standard are expected to show no significant change in their difficulty values over those different years. But the fact that the difficulty values of question papers do show significant variation from year to year (as reported results of many investigations clearly indicate) does not warrant a Board or a University to fix once for all minimum scores for simple pass and/or for different grades of success of the students.

21. Many a time, if not every year, examiners and head examiners are obliged to adjust pass marks in the light of performances of average students in a subject. When they are to agree to a decision for award of grace marks, what they practically do is that they lower the fixed minimum pass marks for different grades of success and adjust these marks according to the exigencies of the situation. People do not react well to this action and take it as a disgrace on the part of the Board and the parties involved. A far better and a more reasonable method might be to adopt the principle that in a particular year the minimum pass marks or cutting marks for different divisions should be worked out from the data on the performances of the examinees and that gradations like 'pass' in different divisions, or 'fail' in total or different subjects of the examination should accordingly be settled. If the minimum marks for a simple pass or for different grades of success, which are so far traditionally fixed, were thus adjusted from year to year, award of grace marks could be made a thing of the past.

22. So long as a pool of standardised question-items of predetermined difficulty values is not built up for each subject of the curriculum on the basis of a thorough and painstaking research of the examination units, and is not made available for the use of the internal and the external paper-setters, the Boards should take up a flexible system, of setting the pass marks from year to year. For each subject, typical questions of a fairly good number and variety should be prepared by examination research units and these should be circulated in schools for the guidance of teachers and students. Such a catalogue of questions must possess, among other crucial characteristics, the qualities, such as, (*a*) they should not repeat, (*b*) they should measure thorough comprehension of the subject and not mere cramming, (*c*) they should cover the entire subject area, and finally, (*d*) they should be suitable for both prognostic and diagnostic tests.

23. Often it is heard that students in examination hall become dissatisfied, if not unruly, when a question paper on a subject appears to them to be more stiff than normal, or is somewhat different from the usual pattern. The candidates under such circumstances are usually pacified by a promise of some kind of consideration in award of marks, although this attempt does not always become successful. We strongly feel that if allotment of marks to question-items as done by the paper-setters were taken as a tentative one and a statement to that effect were made at the top of the question papers, saying that final decision in this regard would be made later at the examiners' and the paper-setter's meetings, much of the discontent and indiscipline among the students could disappear. This recommendation along with the other about fixation of minimum pass marks will tend to bring about a healthy change in the existing system of examination.

24. It is difficult to establish a strong correlation between achievements of men in life and their previous school or college attainments. For, few are the factors which we may consider to work in common with both these types of success. Education in schools and colleges does provide for development or expression opportunities of only a limited number of factors of human mind and ability. The few factors that are called into play here cannot again be claimed to have been measured with precision and reliability in respect of each and every individual by a mass examination. Indeed, can we take it that a large examination of today estimates individual variabilities with sufficient accuracy ? Under the circumstances, it appears ethically wrong to brand once for all a man a 'third', a 'second' or a 'first', simply because he stands low, medium or high in a written or oral chance examination of the kind referred to here. (In India examinations are a large-scale industry. . .examining hundreds of thousands. . .deciding for good the fate of millions. . . Thus is the country provided with guaranteed product—Bhatia, 1959).

25. We like to suggest that successful candidates in an examination should not be ranked in 'first', 'second' or 'third' divisions. Their mark sheets should only show the percentage of subject totals and of the aggregate. This will eliminate the invidious distinction made by the public as well as the authorities themselves between students placed in different divisions. We may go so far as to say that there is practically little necessity of branding 'passes' and 'failures' on the basis of results of public examinations. If a candidate's marks sheet, that is, the record of examination results, shows the percentage scores on different subjects and on the aggregate, there will be much flexibility and freedom in the matter of selection by those who shall either employ them or admit them to higher courses of studies.

26. For carrying out a programme of reform of examinations and for arresting the large number of failures from year to year, the fullest co-operation and participation of class-room teachers in framing the syllabus, in setting the question papers and in the assessment of the answer scripts are very essential. There is a feeling in educational quarters that vagaries of examinations are largely due to the fact that in construction of the curriculum and the syllabus, in selection of question-items for the papers of the external examinations, and in evaluation of student performances, class-room teachers play, if at all, only an insignificant role. Anything done regarding education and examination by men not directly and sufficiently acquainted with the level of attainments of the pupils, nor with the method of teaching and the quality of the teaching personnel, can hardly be sound or educationally fruitful. In Bhopal Seminar in the year 1956, there was a recommendation that in all affairs regarding public examinations more and more co-operation and services of expert school teachers in different subjects of the curriculum should be profitably utilised. It would not be too well to continue the traditional way of conducting examinations or to formulate plans and programmes of education leaving out the field workers, namely, teachers in class-rooms of schools and colleges, who directly deal with the student population and know their individual attainments and abilities.

27. An important cause for large number of failures and low standard of success appears to be that there is practically no screening, nor real selection at any stage of primary or higher education, and this is so in majority of schools. The result is that the accumulated misfits of nine or ten years make their appearance in the final public examinations. Perhaps there is also no admission test worth the name in most of the schools. The annual examination, that is the internal examination held annually for promotion to the next higher class, is not very strictly conducted. So is the case with final test examination which is held for selecting candidates to be sent up for public examinations. Besides these, the quality of teaching method,

teaching personnel and teaching equipment which appear to be below par in majority of schools, are also responsible for the large scale failures and poor performances of students in public examinations. (A reference is made to 'Facilities of Teaching in Higher Secondary Schools in West Bengal' —a Statistical Report based on a survey conducted in 1961 by P. K. Bose and P. Banerjee, Department of Statistics, Calcutta University).

28. A good teaching would mean the 'stimulation, direction and evaluation of learning and thinking by the student', and a good teacher should be able to draw students into active participation in the learning process, and to create confidence in students, through his competence. He has also to (i) acquire good knowledge of subject, (ii) acquire ability to explain subject matter, (iii) evolve a methodical organisation of material, (iv) prepare class notes for each lecture and present it at a moderate speed in clear voice and good pronounciation of words, (v) present blackboard work, sketches, equations etc., in adequately large and distinctly clear writing, (vi) possess a sense of humour, and a cool, collected, non-nervous and natural poise, (vii) have a patient and polite temperament, (viii) be an optimist and an extrovert, (ix) be free from mannerisms, and be responsive to students' questions, and (x) control audience. He continuously learns, he organises his syllabus, he works to a schedule and not just towards the 'completion' of a 'course.' He has to create in each and every student of his class-room independence of thought, originality, keen curiousity and desire to learn. Training of teachers is of course an important item in the educational development plans of the Government, and a large number of school teachers are being trained these days through the training colleges of the country. But mere completion of a course of training in teaching is not enough. As long as a teacher is in profession, he has to strive hard to attain these objectives.

29. In connection with syllabi of newly introduced Higher Secondary Courses upto Class XI, we like to record our feeling that the mathematics and science contents of secondary school curriculum should be increased. A general opinion of those acquainted with the present day secondary school curriculum of our country is that any extension, specially of its mathematics and science content, will result in a course heavier enough for school students of tender age group. While it is difficult to disagree with such views, it is important to note that the curriculum is heavy not because of large course content of the secondary school major subjects, but because of a crowded programme of teaching too many curricular or co-curricular minors that have come within the Course these days. It is far better to have a comparatively few important subjects in the curriculum and to teach them comprehensively than to include in the programme too many subjects and teach them only superficially.

30. A programme for college preparatory mathematics has recently (1959) been produced by a Commission of the College Entrance Examination Board of the United States of America. The mathematics course for the top-most class of the U. S. High Schools Grade-XII, should fairly compare with that for first year of the Five-Year Integrated Engineering Course of our Technological Institutes. But our syllabi fall short both in content and coverage of the subjects. In the course of their work, the Members of the U. S. Commission dealt with (*i*) the nature of contemporary (which they call *new*) mathematics (*ii*) condensation and cutting down of *old* mathematics and possible incorporation of *new* mathematics in secondary school curriculum, and lastly, with (*iii*) the demand for improved instruction. They have also produced some model text books on certain of their recommended subjects. The syllabi produced by them for the top four classes of their Grade-XII High Schools have many striking points of contrast with those of ours in the top three classes of the present day Class-XI schools and first year of our science or engineering colleges. Besides being poor in course content, the syllabus of mathematics which are now being followed in our schools has a noteworthy characteristic of diversification in different courses for science and technical streams of students. Again the mathematics for technical stream is lower in 'theoretical' course content than that for science stream students, although technical stream students are somewhat earmarked for engineering education. American syllabus on the other hand shows no such diversification of mathematical knowledge among students of secondary schools.

31. There is enough scope for improvement of the curriculum of our secondary school mathematics and science courses. Co-ordinated efforts are necessary for framing graded syllabi of the subjects that are studied in school and are followed up further in colleges. Unnecessary repetition and overlapping of topics should be carefully avoided, since they cause wastage of time and energy both at the school as well as at the college level. Without increasing the course length as a whole, and certainly decreasing it wherever possible, how best the mathematics and science content of the curriculum can be improved should be the task before us. College teachers of science and technology often complain that entering freshmen are not properly prepared in mathematics. Also the level of attainments in other important school subjects, they say, is hardly enough to make them college capables. We have yet to develop a balanced course for secondary schools that would lay adequate foundation for college work.

32. To-day the distinction between the humanities and the sciences are sharply drawn ; mathematics holds a unique position ; in many respects it crosses the. boundary of these disciplines ; while it is a tool to the physicists, engineers, and social scientists, it is a creative art to the men of

mathematics. Mathematics has to-day permeated our society and is coming to play in our everyday lives. The first stage of permeation was associated with the study of numbers in all their explicit manifestations in the world around us, and it was a process of abstraction with its application to simple problems. The linear programming of production and quality control in industry are typical of what one might call a second stage in this permeating process. We are moving into a new phase in man's long struggle to control his environment. The necessity for a thorough revision of the programme in mathematics, as a basic element of the programme in science education can no longer be questioned. 'Nuclear energy, exploration of outer space, revolutionary studies of brain-functioning, important new work on the living cell—all point to changes in our lives so startling as to test to the utmost our adaptive capacities. We need an ample supply of high calibre scientists, mathematicians, and engineers....We need quality and we need it in considerable quantity.' (U. S. Commission Report on Mathematics).

33. We feel that not only for the secondary stage, but also for the primary as well as college levels, curriculum planning in mathematics as a whole should form a separate programme of study and research. How far a flexible curriculum may be introduced in this country in terms of the developing needs and the intrinsic abilities of the learners against the background of the needs of the society has to be carefully studied. Keeping in view the relative usefulness of various aspects of knowledge and skill, as also the logical and the psychological nature of learning, and without infringing the traditional autonomy of our educators, we have to find out how far a *liaison* may be established with the large scale employers, the representatives of parents and social welfare workers, in determining, at all the different levels, the areas and the boundaries of the courses. Any research or study unit commissioned with the job of curriculum development and text-book preparation in any of the subjects like mathematics, physics and chemistry, say, should take into its purview the construction of graded syllabi from the bottommost classes of schools to the topmost years of colleges. Repetition and overlapping of topics on any subject, at the school as well as at the college levels can not be controlled if separate commissions, one for primary, one for secondary and one for higher, say, are set up for the job.

34. A question may arise, how far a uniform standard of curriculum in mathematics is capable of developing specific talents. The uniformity of curriculum brings the danger of depriving a student of the opportunity to develop his specific ability. In some countries, a solution of the problem has been found in a system of school circles or student clubs, which work in every school with subjects like mathematics, science, arts and literature, and with some sports. Every secondary school student gets an additional

opportunity to develop and display his or her personal abilities by joining one or more of these circles. In U. S. S. R., the schools are reported to organise at times 'olympiads' in certain of the subjects. There the work of the school circles and such olympiads includes a series of lectures on various topics given by university professors and a written contest in finding solutions of problems or something similar in the subjects concerned. Students are invited to try their abilities and knowledge at the first round of the contest. In the second round, at which more difficult problems are set, come the winners of the first round. The winners of the second round are given prizes and diplomas of honour. There is one olympiad for students of seventh and eighth years, and another for those of the ninth and the tenth years.

35. Because of its direct practical importance, the study of mathematics occupies a stable position in the secondary stage of school curriculum as a compulsory subject. Yet, mathematics is rather a dread and terror to a sizeable percentage of students. What we feel is that a lively interest in the subject may be created and a sense of quantity and accuracy may be grown in the students through the channel of extra-curricular activities. The provision of extracurricular or co-curricular activities as an integral part of the entire activities of the school has been recognised as an essential ingredient of the education for building up of character and development of personality traits, such as, initiative, integrity, persistence, leadership, self-confidence, emotional control and desired social attitude. Of course, a workable solution would depend a great deal on the ingenuity of teachers on whom rests the proper organisation of school activities. The students should be taken into confidence and by a joint collaboration of teachers and students, an enthusiasm will have to be generated for the discovery of the ways and means to dispel the dread for mathematics and to augment through sportive pastime and through an element of competition, the desired interest and aptitude in the subject.

36. Lastly, all suggestions, however important they may be, for improvement of external examinations, would be difficult to implement unless a Board or a University is made to deal with a reasonable size of student population. The present unwieldy size of population of School Final candidates running into a hundred thousand, if not more, is itself a problem, which is a frightening one of gradually increasing 'numbers.' We suggest that no single public examination conducted by any authority like Board or University, should have a population of candidates numbering over ten to fifteen thousand. In that case, the setting of question papers, the assessment of answer scripts, and the performances of candidates may be amenable to a thorough scrutiny, analysis and interpretation.

APPENDICES

Appendix A

Table 1

This Table shows the centres, number of students appearing in each centre of different categories, such as Boys Regular, Boys Private, Girls Regular and Girls Private, and the number of samples taken from each centre. For obtaining this representative sample of candidates, Stratified Random sampling method was followed. Each examination centre was taken as a separate stratum. (The number of strata, i. e., the centres, was found to be very large, 102 to be exact ; and their sizes again varied widely with candidates numbering from 20 to 2000). To collect a ten percent sample of the total number of candidates, ten percent answer papers were selected at random from each of the centres. Ten percent of candidates per centre did not generally mean ten percent of each category.

TABLE NO. 1

Appendix - A

Distribution of Candidates in Compulsory Mathematics of the School Final Examination, 1952, West Bengal, according to Centres for the Aggregate as well as the Sample.

Sl. No. of Centre.	Name of Centre	Aggregate (36914)					Sample (3717)				
		Boys		Girls		Total	Boys		Girls		Total
		Regular	Private	Regular	Private		Regular	Private	Regular	Private	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1.	Agar	386	83	2	2	473	39	7	-	-	46
2.	Aliduar	83	6	1	6	96	9	-	-	-	9
3.	Balur.	206	51	-	4	261	21	5	-	-	26
4.	Belon.	61	2	-	-	63	6	-	-	-	6
5.	Chander.	321	41	16	4	382	30	4	1	-	35
6.	Coo.	274	41	12	6	333	28	4	1	-	33
7.	Dar.	96	113	9	2	220	9	13	-	-	32
8.	Gang.	11	5	5	1	22	1	-	1	-	2
9.	Imphal	50	67	-	-	117	4	6	-	-	10
10.	Jal.	435	30	9	2	476	43	3	1	-	47
11.	Kailagh.	101	19	-	-	120	11	2	-	-	13
12.	Kalim.	57	34	8	1	100	6	4	-	-	10
13.	Kurs.	80	18	3	1	102	8	1	-	-	9
14.	Mal.	370	102	11	1	484	37	10	1	-	48
15.	Port Blair	5	5	-	-	10	1	-	-	-	1
16.	Rai.	127	55	-	2	184	13	5	-	-	18
17.	Sili.	149	7	-	-	156	16	1	-	-	17
18.	Rangoon	-	19	-	4	23	-	2	-	-	2
19.	Bank.	797	104	12	5	918	78	10	1	-	89
20.	Baras.	262	59	6	3	330	27	6	1	-	34
21.	Barrack.	361	145	18	5	529	36	15	1	-	52
22.	Barui.	451	32	5	7	495	46	3	-	-	49
23.	Basir	475	16	2	-	493	47	1	-	-	48
24.	Ber.	649	33	21	3	702	65	4	1	-	70
25.	Birb.	355	117	1	2	475	35	13	-	-	48
26.	Aram.	127	19	1	-	147	13	2	-	-	15
27.	Bang.	148	-	-	2	150	15	-	-	-	15
28.	Bol.	186	5	4	1	196	19	-	1	-	20
29.	Budge	235	1	7	1	244	23	-	-	-	23
30.	Bur.	1092	238	14	2	1346	110	24	1	-	135
31.	Cont.	707	117	-	4	828	71	11		-	82
32.	Diam.	475	20	1	-	496	46	2	1	-	49
33.	Ghat.	182	4	1	1	188	19	-	-	-	19
34.	Jhar.	233	41	6	4	284	23	3	2	-	28
35.	Garh.	228	3	-	1	232	24	-	-	-	24
36.	Hug.	474	207	12	2	695	48	18	-	-	66
37.	Kalna	171	-	4	2	177	18	-	1	-	19
38.	Kamar.	401	15	20	5	441	41	1	-	-	42
39.	Kandi	244	-	-	-	244	25	-	-	-	25
40.	Kat.	591	21	1	2	615	59	2	-	-	61
41.	Kharag.	254	74	-	2	330	28	10	-	-	38
42.	Kri.	419	62	5	6	492	42	6	-	-	48
43.	Pam.	226	24	5	3	258	23	4	-	-	27
44.	Santi.	156	1	-	1	158	16	-	-	-	16
45.	Duraj.	97	8	-	-	105	9	2	-	-	11
46.	How.	1182	374	39	18	1613	108	37	6	1	152
47.	Andul	106	-	1	3	110	11	-	-	1	12
48.	Lal	126	67	-	5	198	14	8	-	-	22
49.	Mid.	663	109	11	1	784	67	11	1	-	79
50.	Naba.	291	13	8	-	312	30	1	-	-	31
51.	Rana.	301	10	5	4	320	33	2	-	-	35
52.	Bishnu.	168	3	-	1	172	17	-	-	1	18
53.	Ser.	821	78	11	6	916	73	7	2	-	82
54.	Taki.	168	8	-	2	178	17	-	-	1	18
55.	Tam.	741	59	10	7	817	73	3	-	-	76

TABLE NO. 1 (Contd.)

Distribution of Candidates in Compulsory Mathematics of the School Final Examination, 1952, West Bengal, according to Centres for the Aggregate as well as the Sample.

Sl. No. of Centre	Name of Centre	Aggregate (36914)					Sample (3717)				
		Boys		Girls		Total	Boys		Girls		Total
		Regular	Private	Regular	Private		Regular	Private	Regular	Private	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
56.	Bhowanipur—A	585	15	35	3	638	60	2	14	2	78
57.	B	218	-	64	7	289	22	-	3	1	26
58.	C	447	-	47	11	505	45	-	3	-	48
59.	D	341	30	26	25	422	35	3	3	2	43
60.	E	320	-	40	18	378	32	-	2	-	34
61.	G	241	10	11	11	273	26	-	2	-	28
62.	H	395	-	26	11	432	40	-	1	1	42
63.	J	-	-	31	6	37	-	-	1	1	2
64.	K	415	43	8	4	470	43	5	-	1	49
65.	L	313	37	1	14	365	32	4	-	3	39
66.	M	258	42	15	2	317	26	4	3	-	33
67.	N	73	78	6	-	157	8	8	2	-	18
68.	Q	-	359	-	-	359	-	36	-	-	36
Bowanipur (Total)		3606	614	310	112	4642	369	62	34	11	476
69.	Calcutta - A	119	81	12	19	231	12	9	1	1	23
70.	B	267	111	43	20	441	27	12	7	1	47
71.	C	205	-	8	25	238	21	-	-	3	24
72.	D	679	102	5	4	790	68	11	-	1	80
73.	E	484	16	35	8	543	49	2	3	-	54
74.	G	185	-	45	5	235	19	-	5	2	26
75.	H	194	-	32	1	227	20	-	4	-	24
76.	J	296	-	13	8	317	30	-	3	-	33
77.	K	400	-	5	6	411	40	-	-	1	41
78.	L	216	34	28	25	303	21	4	5	4	34
79.	M	213	-	12	9	234	22	-	1	-	23
80.	N	228	80	8	15	331	23	8	-	1	32
81.	O	464	34	34	20	552	47	4	4	-	55
82.	R	363	67	-	-	430	37	7	-	-	44
83.	S	345	-	-	-	345	35	-	-	-	35
84.	T	289	-	-	-	289	27	-	-	-	27
85.	V	274	-	-	-	274	28	-	-	-	28
86.	W	360	-	-	-	360	35	-	-	-	35
87.	X	163	72	-	-	235	18	7	-	-	25
88.	Y	181	138	-	-	319	19	15	-	-	34
89.	ZA	310	20	-	-	330	31	2	-	-	33
90.	ZB	287	-	-	-	287	29	-	-	-	29
91.	ZC	396	85	-	-	481	41	8	-	-	49
92.	ZD	454	-	-	-	454	46	-	-	-	46
93.	ZE	-	230	-	-	230	-	23	-	-	23
Calcutta (Total)		7372	1070	280	165	8887	745	112	33	14	904
94.	Syam	165	25	-	-	190	19	2	-	-	21
95.	Asan.	726	71	9	4	810	82	5	1	2	90
96.	Chitta.	103	-	3	1	107	11	-	1	-	12
97.	Bhat.	270	39	-	14	323	35	4	-	-	39
98.	Nai.	333	-	12	-	345	35	-	3	-	38
99.	Kanch.	199	6	9	5	219	22	-	2	3	27
100.	Ulu.	247	-	4	1	252	24	-	-	-	24
101.	Uttar.	285	48	15	2	350	30	5	-	-	35
102.	Jangi.	177	-	-	2	179	19	-	-	-	19
Grand Total		30854	4658	949	453	36914	3122	463	97	35	3717

APPENDIX—A

Table 2

This Table shows district-wise distribution of candidates in Compulsory Mathematics of the School Final Examination, West Bengal, 1952. The fifth and the sixth columns of the table show how far secondary education had spread in different districts of West Bengal in 1952, the year in which the data for the present survey were collected.

TABLE NO. 2 **Appendix - A**

Distribution of Candidates in Compulsory Mathematics of the School Final Examination, 1952, West Bengal, for the Total as well as Sample according to Locality

Locality	Aggregate (36914)						Sample 3717)					
	Boys		Girls		Total	Percentage	Boys		Girls		Total	Percentage
	Regular	Private	Regular	Private			Regular	Private	Regular	Private		
Burdwan	2683	330	31	11	3055	8.3	280	31	3	3	317	8.5
Birbhum	864	154	10	6	[illegible]	2.8	86	19	1	–	106	2.8
Bankura	965	107	12	6	1090	3.0	95	10	1	1	107	2.8
Hooghly	2028	393	55	14	2490	6.7	194	36	3	–	233	6.3
Howrah	1535	374	44	22	1975	5.4	143	37	6	2	188	5.1
Midnapur	3008	407	28	20	3463	9.4	305	38	3	–	346	9.3
Burdwan Division	11083	180	79	79	13107	35.5	1103	171	17	6	1297	34.9
Bhowanipore	3606	614	310	112	4642	12.6	369	62	34	11	476	12.8
Calcutta	7372	1070	280	165	8887	24.1	745	112	33	14	904	24.3
Cooch-Behar	274	41	12	6	333	0.9	28	4	1	–	33	0.9
Darjeeling	382	172	20	4	578	1.6	39	19	–	–	58	1.6
Dinajpur	333	106	–	6	445	1.2	34	10	–	–	44	1.2
Jalpaiguri	518	36	10	8	572	1.6	52		1		56	1.5
Maldah	370	102	11	1	484	1.3	37	10	1	–	48	1.3
Murshidabad	1192	100	21	10	1323	3.6	123	12	1	–	136	3.7
Nadia	1167	86	18	11	1282	3.5	121	9	–	–	130	3.5
24 Pargs.	3778	341	80	44	4243	11.5	390	32	8	4	434	11.7
Presidency Division	18992	2668	762	367	22789	61.7	1938	278	79	29	2319	62.4
Manipur	50	67	–	–	117	0.3	4	6	–	–	10	0.3
Port Blair	5	5	–	–	10	0.0	1	–	–	–	1	0.0
Rangoon	–	19	–	4	23	0.1	–	2	–	–	2	0.1
Sikkim	11	5	5	1	22	0.1	1	–	1	–	2	0.1
Syam	165	25	–	–	190	0.5	19	2	–	–	21	0.6
Tippera	548	104	2	2	656	1.8	56	9	–	–	65	1.8
Grand Total	30854	4658	949	453	36914	100.0	3122	463	97	35	3717	100.0

Appendix B

Table 1 refers to performances of regular students only, both Boys and Girls, showing the description of thirty-one question-items in the question paper, the number of passes, the number of failures and the number of non-attempts in respect of each question-item. These figures have again been shown in terms of percentages of the number of samples and the number of attempts on each item. This Table shows that there are some items on which the percentage of passes is very high whereas on some other items it is exceptionally low.

Table 2 refers to performances of private students, both Boys and Girls, showing the description of thirty-one question-items in the question paper, the number of passes, the number of failures, and the number of non-attempts in respect of each question-item. These figures have again been shown in terms of percentages of the number of samples and the number of attempts on each item. This Table also shows that there are some items on which the percentage of passes is very high whereas on some other items it is exceptionally low.

The 31 tables, **Table 3** to **Table 33** refer to thirty-one question-items on Compulsory Mathematics on which candidates' performances have been studied. Each of these Tables shows the figures from which the graph has been drawn and the values given in marginal notes have been extracted. They all show, at a glance, ten important aspects of candidates' performances on each question-item as listed below :

> 1. Allotted Mark on the Item. 2. Average Score. 3. S. D. (Standard Deviation). 4. C. V. (Coefficient of Variation). 5. Comparative scores on the Item and on the Aggregate. 6. Discriminating Powers of the Item at 30, 50, 60 and 80 per cent levels. 6. Maximum Discriminating Power and the corresponding Level of Discrimination. 8. Average Difficulty Value of the Item. 9. Optimum Marks. 10. The Item-score graph showing 30, 50, 60 and 80 per cent score points on the item with the four corresponding levels on the ability scale i.e. aggregate score.

The Difficulty Value of a question-item has been estimated by six different methods. The figure quoted here is described as 'Average Difficulty Value', because it is the arithmetic mean of the six values referred to above.

The highest of the four discriminating powers corresponding to the four grades of success has been termed here as the 'Maximum Discriminating Power.'

Appendix - B

TABLE NO. 1

Showing for REGULAR STUDENTS the number and percentage of attempts, successes and failures in different question-items of the Compulsory Mathematics paper of the 1952-Examination of the Board of Secondary Education, West Bengal.

Question-Items	Sample Size - 3219					Percentage(to sample total)				Percentage (to total attempts)		
	Passes with marks		Failures	Total	Non-attempts	Passes with marks		Failures	Non-attempts	Passes with marks		Failures
	30–79	80–				30–79	80–			30–79	80–	
Arithmetic:												
1 Simplification	7	2325	514	2846	373	0.2	72.2	16.0	11.6	0.2	81.7	18.1
2(a) L.C.M. Problem	4	819	250	1073	2146	0.1	25.4	7.8	66.7	0.4	76.3	23.3
(b) Profit & Loss	2	224	155	381	2838	0.06	7.0	4.8	88.2	0.5	58.8	40.7
or(c) Square-root Problem	7	1423	147	1577	1642	0.2	44.2	4.6	51.0	0.4	90.2	9.3
(d) Time & Work Prob.	18	1700	150	1868	1351	0.6	52.8	4.7	42.0	1.0	91.0	8.0
3(a) Practice	210	2281	441	2932	287	6.5	70.9	13.7	8.9	7.2	77.8	15.0
(b) Fencing & Papering	32	1353	624	2009	1210	1.0	42.0	19.4	37.6	1.6	67.3	31.1
or(c) Percentage Problem	1	146	19	166	3053	0.03	4.5	0.6	94.8	0.6	88.0	11.4
(d) Alligation Problem	0	159	14	173	3046	0.00	4.9	0.4	94.6	0.0	91.9	8.1
4(a) Time & Distance	0	29	81	110	3109	0.00	1.0	2.5	96.6	0.0	26.4	73.6
or(b) Stock & Share Prob.	7	832	342	1181	2038	0.2	25.8	10.6	63.3	0.6	70.4	29.0
Algebra:												
5(a) Factorisation	430	1864	75	2369	850	13.4	57.9	2.3	26.4	18.1	78.7	3.2
(b) L.C.M. (Algebra)	10	1166	660	1836	1383	0.3	36.2	20.5	43.0	0.5	63.5	35.9
or(c) Identify (Substitution)	10	633	62	705	2514	0.3	19.7	1.9	78.1	1.4	89.8	8.8
(d) Equation Problem	2	262	235	499	2720	0.06	8.1	7.3	84.5	0.4	52.5	47.1
6(a) Square-root (Algebra)	0	147	53	200	3019	0.00	4.6	1.6	93.8	0.0	73.5	26.5
(b) Ratio & Proportion	0	32	82	114	3105	0.00	1.0	2.5	96.5	0.0	28.1	71.9
or(c) Cyclic Factorization	4	135	621	760	2459	0.1	4.2	19.3	76.4	0.5	17.8	81.7
(d) Equation Problem	22	1292	302	1616	1603	0.7	40.1	9.4	49.8	1.3	80.0	18.7
7 Graph	832	1917	219	2968	251	25.8	59.6	6.8	7.8	28.0	64.6	7.4
Geometry												
8(a) Theorem 11 (Book I)	207	2385	285	2877	342	6.4	74.1	8.9	10.6	7.2	82.9	9.9
(b) Exercise on Above	99	530	689	1318	1901	3.1	16.5	21.4	59.1	7.5	40.2	52.3
or(c) Theorem 26 (Book II)	29	200	26	255	2964	1.0	6.2	0.8	92.1	11.4	78.4	10.2
(d) Exercise on Above	7	22	62	91	3128	0.2	0.7	1.9	97.2	7.7	24.2	68.1
9(a) Theorem 16 (Book I)	219	2499	246	2964	255	6.8	77.6	7.6	7.9	7.4	84.3	8.3
(b) Exercise on Above	18	144	267	429	2790	0.6	4.5	8.3	86.7	4.2	33.6	62.2
or(c) Theorem 32 (Book III)	16	53	18	87	3132	0.5	1.6	0.6	97.3	18.4	60.9	20.7
(d) Exercise on Above	6	13	31	50	3169	0.2	0.4	1.0	98.4	12.0	26.0	62.0
10(a) Triangle Construction	68	837	468	1373	1846	2.1	26.0	14.5	57.3	4.9	61.0	34.1
(b) Locus Finding	70	53	113	236	2983	2.2	1.6	3.5	92.7	29.7	22.4	47.9
or(c) Inscribing a Triangle	49	81	75	205	3014	1.5	2.5	2.3	93.6	23.9	39.5	36.6

TABLE NO 2

Showing for PRIVATE STUDENTS, the number and percentage of attempts, successes and failures in different question-items of the Compulsory Mathematics paper of the 1952-Examination of the Board of Secondary Education, West Bengal.

Question - Items		Sample Size – 498					Percentage to sample total				Percentage to total attempts		
		Passes with marks		Failures	Total	Non attempts	Passes with marks		Failures	Non-attempts	Passes with marks		Failures
		30–79	80–				80–79	80–			30–79	80–	
Arithmetic													
1	Simplification	0	344	88	432	66	0.0	69.1	17.7	13.3	0.0	79.6	20.4
2(a)	L.C.M. Problem	2	148	45	195	303	0.4	29.7	9.0	60.8	1.0	75.9	23.1
(b)	Profit & Loss	1	38	32	71	427	0.2	7.6	6.4	85.7	1.4	53.5	45.1
or (c)	Square-root Problem	3	185	30	218	280	0.6	37.1	6.0	56.2	1.4	84.9	13.7
(d)	Time & Work Prob.	2	214	33	249	249	0.4	43.0	6.6	50.0	0.8	85.9	13.2
3(a)	Practice	4	388	72	464	34	0.8	77.9	14.5	6.8	0.9	83.6	15.5
(b)	Fencing & Papering	6	183	102	291	207	1.2	36.7	20.5	41.6	2.0	62.9	35.1
or (c)	Percentage Problem	0	10	2	12	486	0.0	2.0	0.4	97.6	0.0	83.3	16.7
(d)	Alligation Problem	0	15	2	17	481	0.0	3.0	0.4	96.7	0.0	88.2	11.8
4(a)	Time & Distance	0	4	16	20	478	0.0	0.8	3.2	96.0	0.0	80.0	20.0
or (b)	Stock & Share Prob.	0	67	46	113	385	0.0	13.5	9.2	77.3	0.0	59.3	40.7
Algebra.													
5(a)	Factorisation	0	158	113	271	227	0.0	31.7	22.7	45.6	0.0	58.3	41.7
(b)	L.C.M.(Algebra)	0	158	113	271	227	0.0	31.7	22.7	45.6	0.0	58.3	41.7
or (c)	Identify (Substitution)	0	67	10	77	421	0.0	13.5	2.0	84.5	0.0	87.0	13.0
(d)	Equation Problem	0	22	34	56	442	0.0	4.4	6.8	88.8	0.0	39.3	60.7
6(a)	Square-root (Algebra)	0	12	6	18	480	0.0	2.4	1.2	96.4	0.0	66.7	33.3
(b)	Ratio & Proportion	1	2	17	20	478	0.2	0.4	3.4	96.0	5.0	10.0	85.0
or (c)	Cyclic Factorization	0	11	109	120	378	0.0	2.2	21.9	75.9	0.0	9.2	90.8
(d)	Equation Problem	1	140	50	191	307	0.2	28.1	10.0	61.6	0.5	73.3	26.2
7	Graph	158	244	38	440	58	31.7	49.0	7.6	11.6	35.9	55.5	8.6
Geometry :													
8(a)	Theorem 11 (Book I.	65	321	61	447	51	13.1	64.4	12.2	10.2	14.5	71.8	13.6
(b)	Exercise on Above	17	47	109	173	325	3.4	9.4	21.9	65.3	9.8	27.2	63.0
or (c)	Theorem 26 (Book II)	3	22	3	28	470	0.6	4.4	0.6	94.4	10.7	78.6	10.7
(d)	Exercise on Above	0	2	8	10	488	0.0	0.4	1.6	98.0	0.0	20.0	80.0
9(a)	Theorem 16 (Book I)	53	338	73	464	34	10.6	67.9	14.7	6.8	11.4	72.8	15.7
(b)	Exercise on Above	0	8	33	41	457	0.0	1.6	6.6	91.8	0.0	19.5	80.5
or (c)	Theorem 32 (Book III)	0	4	5	9	489	0.0	0.8	1.0	98.2	0.0	44.4	55.6
(d)	Exercise on Above	0	0	1	1	497	0.0	0.0	0.2	99.8	0.0	0.0	100.0
10(a)	Triangle Construction	0	94	84	178	320	0.0	18.9	16.9	64.3	0.0	52.8	47.2
(b)	Locus Finding	6	4	9	19	479	1.2	0.8	1.8	96.2	31.6	21.0	47.4
or (c)	Inscribing a Triangle	5	2	16	23	475	1.0	0.4	3.2	95.4	21.7	8.7	69.6

Q. 1. Simplification Problem in Arithmetic

Allotted Mark	Average Score	S. D.	C. V.
5	4.1	1.93	48

Students capable of securing

19	29	34	49

on the Full Paper can score

30	50	60	80

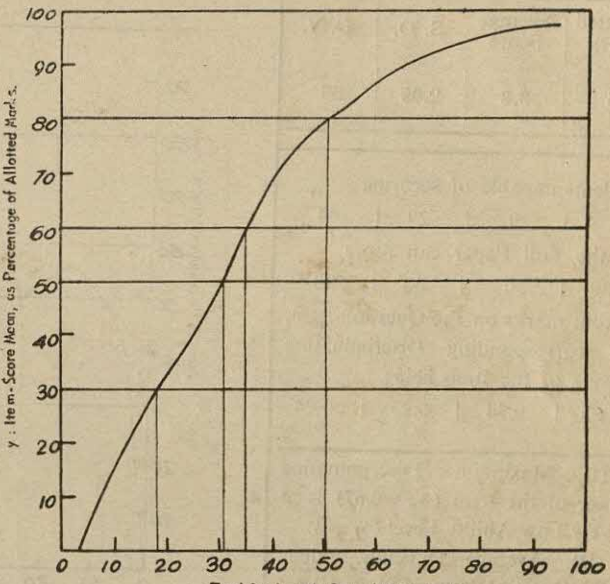
percent marks on the Question-item, the correponding Discriminating Powers of the Item being

0.66	0.51	0.45	0.33

(I). Maximum Discriminating Power of this Item ($\delta_p = 0.66$) is at a Low Ability Level ($\delta_L = 19$).

(II). Average Difficulty Value of the Question-Item is ($\delta_v = 0.28$).

(III). The item was allotted 5 marks, but it appears to deserve an Optimum of 3 marks only.



Discriminating Graph for Q. 1 on Simplification in Arithmetic.

TABLE NO. 3

Showing performances of candidates in Question 1, a simplification problem involving fundamental arithmetical operations on fractional and decimal quantities.

Marks obtained in Comp. Mathematics	No. of Candidates Paper	Candidates attempting		Number and percentage (to candidates attempting) of securing marks.												Average Marks secured	
		No.	p.c. to total	0		1		2		3		4		5		Actual	In % of Allotted Marks
				No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.		
0-09	72	21	29.1	21	100.0											0.00	00.0
10-19	121	76	62.8	50	65.8									26	34.2	1.71	34.2
20-29	190	140	73.7	67	47.9			1	0.7			1	0.7	71	50.7	2.58	51.5
30-39	759	617	81.3	175	28.4	4	0.6	2	0.3			13	2.1	423	68.6	3.53	70.5
40-49	938	850	90.6	147	17.3					3	0.4	18	2.1	682	80.2	4.11	82.1
50-59	752	704	93.6	86	12.2					1	0.1	10	1.4	607	86.2	4.73	87.4
60-69	461	449	97.4	33	7.3							10	2.2	406	90.4	4.61	92.2
70-79	264	262	99.2	15	5.7							2	0.8	245	93.5	4.71	94.1
80-89	123	122	99.2	3	2.5							1	0.8	118	96.7	4.87	97.3
90–	37	37	100.0	1	2.7									36	97.3	4.87	97.3
Total	3717	3276	88.2	598	18.3	4	0.1	3	0.1	4	0.1	55	1.7	2614	79.7	4.06	81.2
Boys (R)	3122	2756	88.3	497	18.0	3	0.1	3	0.1	4	0.2	47	1.7	2202	79.9	4.07	81.4
Boys (P)	463	401	86.6	79	19.7	1	0.3	–	–	–	–	5	1.2	316	78.8	3.99	79.8
Girls (R)	97	90	92.8	14	15.6	–	–	–	–	–	–	2	2.2	74	82.2	4.20	84.0
Girls (P)	35	31	88.6	8	25.8	–	–	–	–	–	–	1	3.2	22	71.0	3.68	73.6
Total	3717	3278	88.2	598	18.2	4	0.1	3	0.1	4	0.1	55	1.7	2614	79.7	4.06	81.2

Q.1. Simplify : 5

$$1 + \frac{1}{1 + \frac{1}{1 + 1/3}} + \frac{3\frac{1}{2} \div 2\frac{1}{2} \times 1\frac{1}{2}}{3\frac{1}{2} \div 2\frac{1}{2} \text{ of } 1\frac{1}{2}} \div 5.25$$

Q. 2(a) L. C. M. Problem in Arithmetic

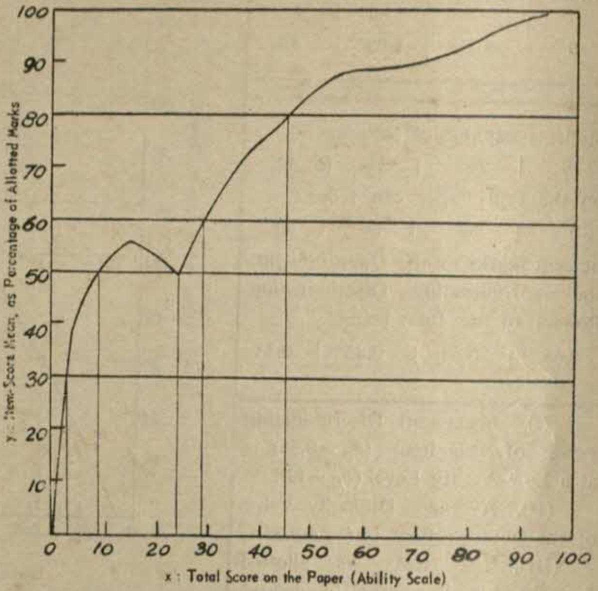
Allotted Mark	Average Score	S. D.	C. V.
5	**3.8**	**2.09**	**55**

Students capable of securing
4 | 9 | 29 | 44
on the Full Paper can score
30 | 50 | 60 | 80
percent marks on the Question-item, the corresponding Discriminating Powers of the Item being
0.67 | 0.34 | 0.29 | 0.24

(I). Maximum Discriminating Power of the Item ($\delta_p = 0.67$) is at a very Low Ability Level ($\delta_L = 4$).

(II). Average Difficulty Value of the Question-Item is ($\delta_v = 0.33$).

(III). The item was allotted 5 marks, but it appears to deserve an Optimum of 3 marks only.



Discriminating Graph for Q.2(a) on L.C.M. Problem in Arithmetic.

TABLE NO. 4

Appendix - B

Showing performances of candidates in Q.2(a), a Problem on Lowest Common Multiple in Arithmetic.

Marks obtained in Comp. Mathematics	No. of Candidates for the paper	Candidates attempting		Number and percentage (to candidates attempting) of securing Marks.												Average Marks secured	
				0		1		2		3		4		5			
		No.	p.c. to total	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	Actual	In % of Allotted Marks
0- 09	72	18	25.0	11	61.1									7	38.9	1.95	38.9
10- 19	121	46	38.0	20	43.5							2	4.4	24	52.2	2.79	55.7
20- 29	190	81	42.6	40	49.4					1	1.2	5	6.2	35	43.2	2.45	48.9
30- 39	759	334	44.0	101	30.2					2	0.6	17	5.1	214	64.1	3.43	68.5
40- 49	938	365	38.9	77	21.1					1	0.3	18	4.9	269	73.7	3.89	77.8
50- 59	782	232	30.9	28	12.1					2	0.9	11	4.7	191	82.3	4.33	86.6
60- 69	461	119	25.8	13	10.9							6	5.0	100	84.0	4.40	88.0
70- 79	264	40	15.2	4	10.0									36	90.0	4.50	90.0
80- 89	123	24	19.5	1	4.2									23	95.8	4.79	95.8
90-	37	9	24.3									1	11.1	8	88.9	4.89	97.8
Total	3717	1268	34.2	295	23.3					6	0.5	60	4.7	907	71.5	3.78	75.6
Boys (R)	3122	1049	33.6	242	23.1					4	0.4	46	4.4	757	72.2	3.79	75.8
Boys (P)	463	185	40.0	44	23.8					2	1.1	12	6.5	127	68.6	3.72	74.4
Girls (R)	97	24	24.7	8	33.3							1	4.2	15	62.5	3.29	65.8
Girls (P)	35	10	28.6	1	10.0							1	10.0	8	80.0	4.40	88.0
Total	3717	1268	34.1	295	23.3					6	0.5	60	4.7	907	71.5	3.78	75.6

Q.2. Either, (a). Find the least number which when divided by 35 leaves a remainder 25, when divided by 45 leaves 35 and when divided by 55, leaves 45. 5

Q. 2(b) Profit & Loss Problem in Arithmetic

Allotted Mark	Average Score	S. D.	C. V.
5	2.9	2.44	85

Students capable of securing

29	44	49	79

on the Full Paper can score

30	50	60	80

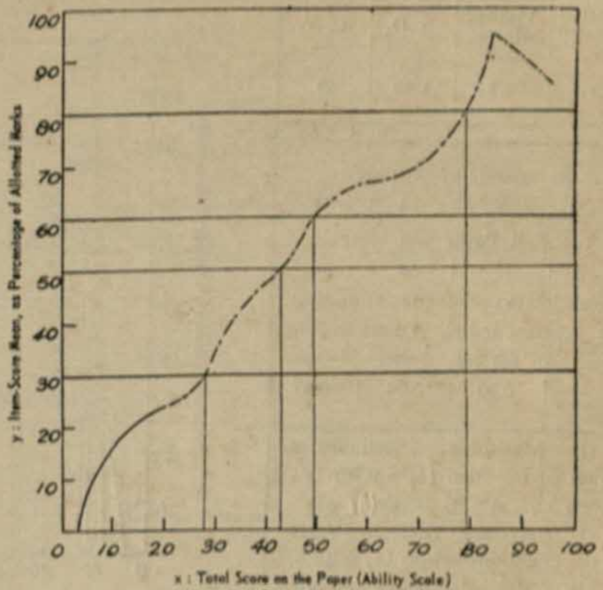
percent marks on the Question-item, the correponding Discriminating Powers of the Item being

0.64	0.50	0.47	0.36

(I). Maximum Discriminating Power of this Item ($\delta_p = 0.64$) is at a Low Ability Level ($\delta_L = 29$).

(II). Average Difficulty Value of the Question-Item is ($\delta_v = 0.82$).

(III). The item was allotted 5 marks, but it appears to deserve an Optimum of 9 marks only.



Discriminating Graph for Q.2(b) on Profit & Loss Problem in Airthmetic.

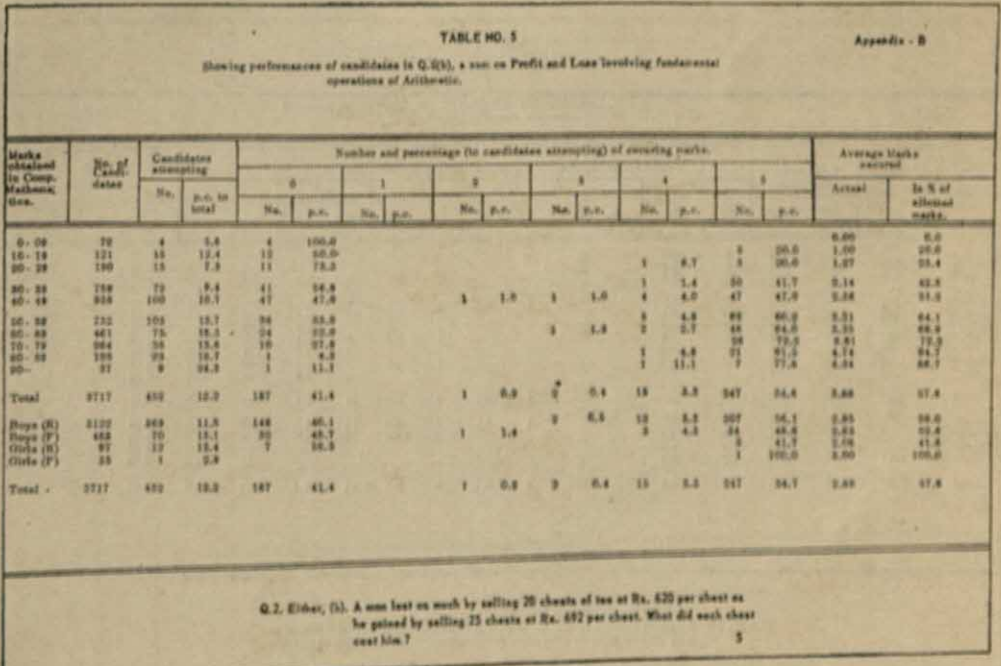


TABLE NO. 5

Appendix - B

Showing performances of candidates in Q.2(b), a sum on Profit and Loss involving fundamental operations of Arithmetic.

Q.2. Either, (b). A man lost as much by selling 20 chests of tea at Rs. 620 per chest as he gained by selling 25 chests at Rs. 692 per chest. What did each chest cost him? 5

Q. 2(c) Square Root Problem in Arithmetic

Allotted Mark	Average Score	S. D.	C. V.
5	4.5	1.49	33

Students capable of securing

9 | 9 | 14 | 34

on the Full Paper can score

30 | 50 | 60 | 80

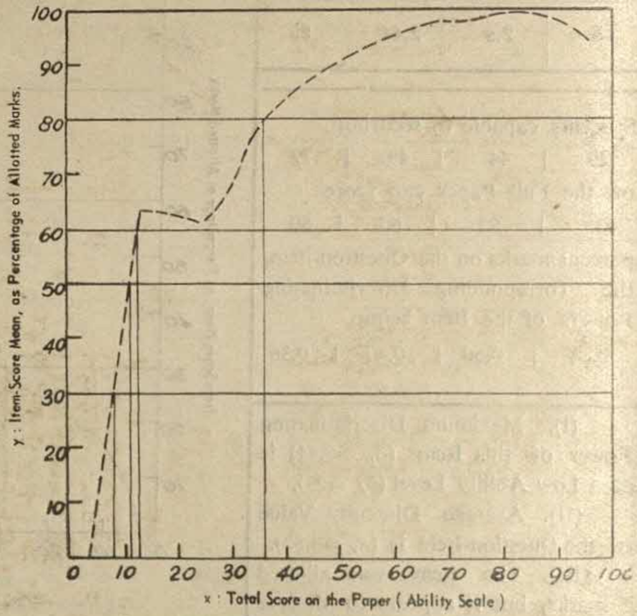
percent marks on the Question-item, the corresponding Discriminating Powers of the Item being

0.90 | 0.90 | 0.74 | 0.35

(I). Maximum Discriminating Power of the Item (δ_p =0.90) is at a very Low Ability Level ($_L$ =9).

(II). Average Difficulty Value of the Question-Item is (δ_v =0.30).

(III). The item was allotted 5 marks, but it appears to deserve an Optimum of 3 marks only.



Discriminating Graph for Q. 2(c) on Square-root Problem in Arithmetic

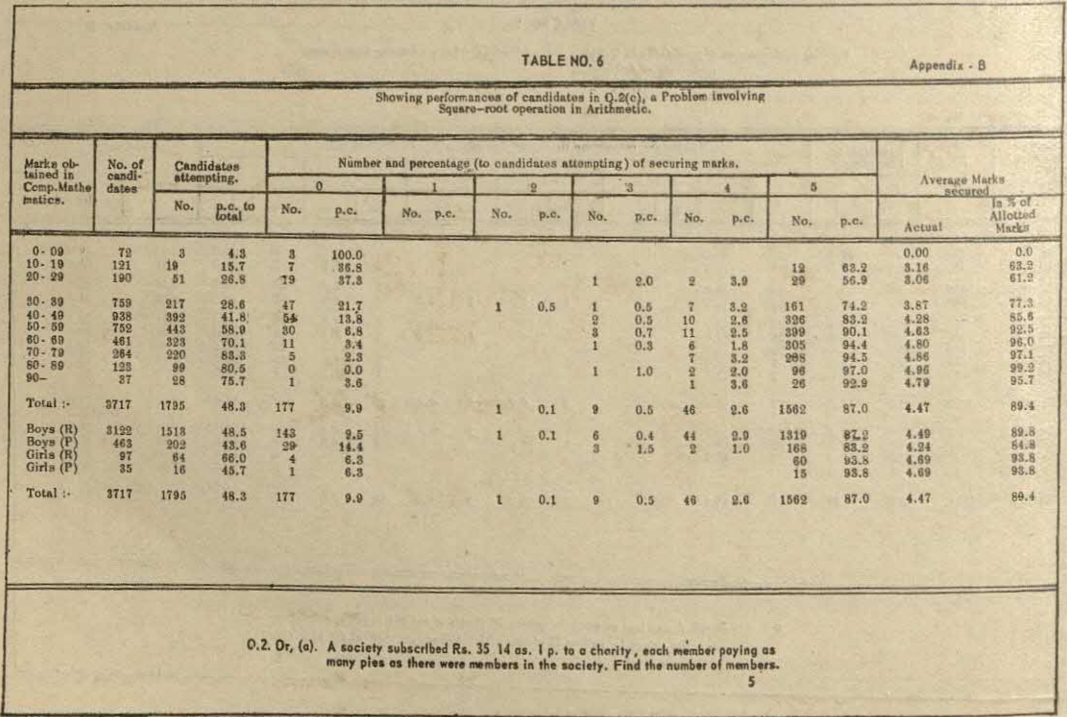


TABLE NO. 6

Appendix - B

Showing performances of candidates in Q.2(c), a Problem involving Square-root operation in Arithmetic.

Marks obtained in Comp.Mathematics.	No. of candidates	Candidates attempting.		Number and percentage (to candidates attempting) of securing marks.												Average Marks secured	
				0		1		2		3		4		5			
		No.	p.c. to total	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	Actual	In % of Allotted Marks
0- 09	72	3	4.3	3	100.0											0.00	0.0
10- 19	121	19	15.7	7	36.8									12	63.2	3.16	63.2
20- 29	190	51	26.8	19	37.3					1	2.0	2	3.9	29	56.9	3.06	61.2
30- 39	759	217	28.6	47	21.7			1	0.5	1	0.5	7	3.2	161	74.2	3.87	77.3
40- 49	938	392	41.8	54	13.8					2	0.5	10	2.6	326	83.2	4.28	85.6
50- 59	752	443	58.9	30	6.8					3	0.7	11	2.5	399	90.1	4.63	92.5
60- 69	461	323	70.1	11	3.4					1	0.3	6	1.8	305	94.4	4.80	96.0
70- 79	264	220	83.3	5	2.3							7	3.2	208	94.5	4.86	97.1
80- 89	123	99	80.5	0	0.0					1	1.0	2	2.0	96	97.0	4.96	99.2
90–	37	28	75.7	1	3.6							1	3.6	26	92.9	4.79	95.7
Total :-	3717	1795	48.3	177	9.9			1	0.1	9	0.5	46	2.6	1562	87.0	4.47	89.4
Boys (R)	3122	1518	48.5	143	9.5			1	0.1	6	0.4	44	2.9	1319	87.2	4.49	89.8
Boys (P)	463	202	43.6	29	14.4					3	1.5	2	1.0	168	83.2	4.24	84.8
Girls (R)	97	64	66.0	4	6.3									60	93.8	4.69	93.8
Girls (P)	35	16	45.7	1	6.3									15	93.8	4.69	93.8
Total :-	3717	1795	48.3	177	9.9			1	0.1	9	0.5	46	2.6	1562	87.0	4.47	89.4

Q.2. Or, (a). A society subscribed Rs. 35 14 as. 1 p. to a charity, each member paying as many pies as there were members in the society. Find the number of members.

5

Q· 2(d) Time and Work Problem in Arithmetic

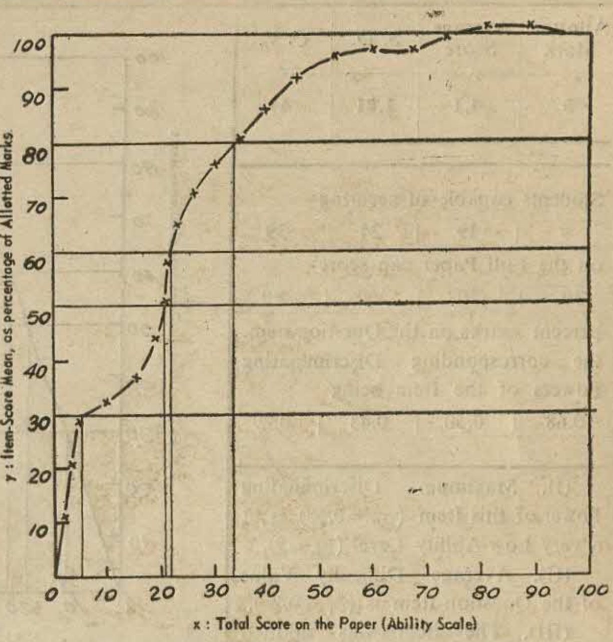
Allotted Mark	Average Score	S. D.	C. V.
5	4.5	1.41	31

Students capable of securing			
4	19	19	34
on the Full Paper can score			
30	50	60	80
percent marks on the Question-item, the corresponding Discriminating Powers of the Item being			
0.75	0.48	0.48	0.34

(I). Maximum Discriminating Power of the Item ($\delta_p = 0.75$) is at a very Low Ability Level ($\delta_L = 19$).

(II). Average Difficulty Value of the Question-Item is ($\delta_p = 0.16$).

(III). The item was allotted 5 marks, but it appears to deserve an Optimum of 2 marks only.



Discriminating Graph for Q. 2(d) on Time & Work Problem in Arithmetic

TABLE NO. 7

Appendix - B

Showing performances of candidates in Q.2(d), a Problem involving Unitary Method on Time and Work in Arithmetic.

Marks obtained in Comp.Mathematics.	No. of candidates	Candidates attempting		Number and percentage (to candidates attempting) of securing marks.												Average Marks secured.	
				0		1		2		3		4		5			
		No.	p.c. to total	No.	p.c.	No.	P.c.	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	Actual	In % of Allotted Marks
0- 09	72	10	13.9	7	70.0							1	10.0	2	20.0	1.40	28.0
10- 19	121	45	37.2	29	64.4					1	0.2	1	0.2	14	35.2	1.78	35.5
20- 29	190	67	35.3	21	31.3			1	1.5	1	1.5	2	8.0	42	62.6	3.33	66.5
30- 39	759	308	40.6	59	19.2			4	1.3	3	1.0	17	5.5	225	73.1	3.93	78.6
40- 49	938	500	53.3	43	8.6					6	1.2	13	2.6	438	87.6	4.52	90.4
50- 59	752	502	66.8	12	2.4					4	0.8	6	1.2	480	95.6	4.85	97.0
60- 69	461	339	73.5	10	2.9							10	2.9	319	94.1	4.82	96.4
70- 79	264	219	83.0	2	0.9							7	3.2	210	95.9	4.93	98.5
80- 89	123	99	80.5									2	2.0	97	98.0	4.98	99.6
90–	37	28	75.7									1	3.6	27	96.4	4.97	99.3
Total :-	3717	2117	57.0	183	8.6			5	0.2	15	0.7	60	2.8	1854	87.6	4.52	90.4
Boys (R)	3122	1800	57.7	144	8.0			5	0.3	13	0.7	56	3.1	1582	87.9	4.55	91.0
Boys (P)	463	229	49.5	31	13.5					2	0.9	4	1.8	192	83.8	4.29	85.8
Girls (R)	97	68	70.1	6	8.8									62	91.2	4.56	91.2
Girls (P)	35	20	57.1	2	10.0									18	90.0	4.50	90.0
Total :-	3717	2117	57.0	183	8.6			5	0.2	15	0.7	60	2.8	1854	87.6	4.52	90.4

Q.2. Or (b). If A does a piece of work in 6 days which B can do in 10 days and C can do in 15 days, in what time will they do it all working together? 5

Q. 3(a) Practice Problem in Arithmetic

Allotted Mark	Average Score	S. D.	C. V.
5	4.1	1.81	44

Students capable of securing

9	19	24	39

on the Full Paper can score

30	50	60	80

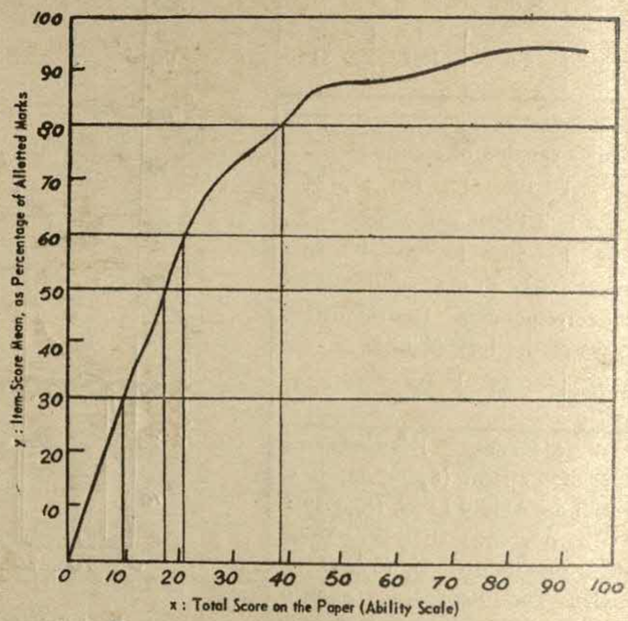
percent marks on the Question-item, the corresponding Discriminating Powers of the Item being

0.68	0.50	0.43	0.29

(I). Maximum Discriminating Power of this Item ($\delta_p = 0.68$) is at a very Low Ability Level ($\delta_L = 9$).

(II). Average Difficulty Value of the Question-Item is ($\delta_v = 0.20$).

(III). The item was allotted 5 marks, but it appears to deserve an Optimum of 2 marks only.



Discriminating Graph for Q.3(a) on Practice Problem in Arithmetic

TABLE NO.8

Appendix - B

Showing performances of candidates in Q.3(a), a Problem on Simple Practice in Arithmetic.

Marks obtained in Comp.Mathematics.	No. of candidates	Candidates attempting		Number and percentage (to candidates) attempting of securing marks												Average Marks secured	
				0		1		2		3		4		5			
		No.	p.c. to total	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	Actual	In p.c. of allotted marks.
0- 09	72	35	48.7	28	80.0					4	11.4			3	8.6	0.77	15.4
10- 19	121	110	90.9	60	54.5					9	8.2	5	4.5	36	32.7	2.06	41.2
20- 29	190	180	94.7	52	28.9					19	10.6	3	1.7	106	58.9	3.33	66.6
30- 39	759	715	94.2	146	20.4	1	0.1	4	0.6	51	7.1	13	1.8	500	69.9	3.80	75.9
40- 49	938	888	94.7	106	11.9					50	5.6	13	1.5	719	81.0	4.28	85.6
50- 59	752	707	94.0	64	9.1					67	9.5	11	1.6	565	79.9	4.35	86.9
60- 69	461	419	90.9	38	9.1					20	4.8	7	1.7	354	84.5	4.44	88.7
70- 79	264	226	85.6	13	5.8					10	4.4	5	2.2	198	87.6	4.60	92.0
80- 89	123	91	74.0	4	4.4					4	4.4	2	2.2	81	89.0	4.67	93.4
90 –	37	25	67.6	1	4.0					2	8.0			22	88.0	4.64	92.8
Total	3717	3396	91.4	512	15.1	1	0.03	4	0.1	236	6.9	59	1.7	2584	76.1	4.08	81.6
Boys (R)	3122	2847	91.2	417	14.6			3	0.1	198	6.9	45	1.6	2184	76.7	4.11	82.2
Boys (P)	463	433	93.5	62	14.3	1	0.2			25	5.8	11	2.5	334	77.1	4.13	82.6
Girls (R)	97	85	87.6	24	28.2					9	10.6	2	2.4	50	58.8	3.35	67.0
Girls (P)	35	31	88.6	9	29.0			1	3.2	4	12.9	1	3.2	16	51.6	3.16	63.2
Total:-	3717	3396	91.4	512	15.1	1	0.03	4	0.1	236	6.9	59	1.7	2584	76.1	4.08	81.6

Q.3. Either, (a). Find, by practice, the value of 13 sacks of flour each weighing 3 mds. 27 seers 8 ch. at Rs. 10 5 as. 6p. per maund. 5

Q· 3(b) Fencing and Papering Problem in Arithmetic

Allotted Mark	Average Score	S. D.	C. V.
5	3.3	2.28	69

Students capable of securing

24	39	49	59

on the Full Paper can score

30	50	60	80

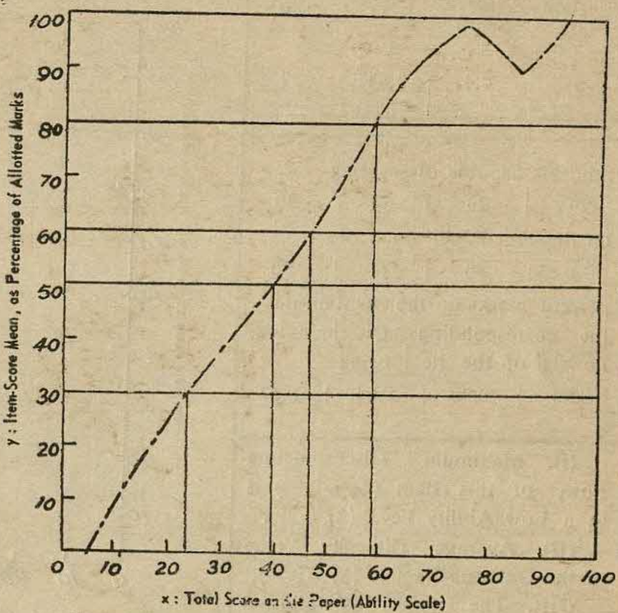
percent marks on the Question-item, the corresponding Discriminating Powers of the Item being

0.71	0.55	0.48	0.35

(I). Maximum Discriminating Power of the Item (δ_p =0.71) is at a Low Ability Level (δ_L =24).

(II). Average Difficulty Value of the Question-Item is (δ_p =0.56).

(III). The item was allotted 5 marks, but it appears to deserve an Optimum of 6 marks only.



Discriminating Graph for Q.3(b) of Fencing & Papering Problem in Arithmetic

TABLE NO. 9

Appendix - B

Showing performances of candidates in Q.3(b), a Problem on Measurement of Area, Fencing & Papering in Arithmetic.

Marks obtained in Comp.Mathematics.	No. of Candidates.	Candidates attepmting		Number and percentage (to candidates attempting) of securing marks.												Average Marks secured	
				0		1		2		3		4		5			
		No.	p.c.to total	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	Actual	In % of Allotted Marks
0-09	72	12	16.7	12	100.0											0.00	0.0
10-19	121	38	31.4	30	78.9					1	2.6	4	10.5	3	7.9	0.90	17.9
20-29	190	70	36.8	47	67.1							4	5.7	19	27.1	1.58	31.7
30-39	759	327	43.1	173	52.9			2	0.6	7	2.1	33	10.1	112	34.3	2.20	43.9
40-49	938	560	59.7	221	39.5	1	0.2			12	2.1	52	9.3	274	48.9	2.88	57.6
50-59	752	574	76.3	141	24.6			1	0.2	8	1.4	40	7.0	384	66.9	3.67	73.4
60-69	461	384	83.3	64	16.7					5	1.3	27	7.0	288	75.0	4.07	81.4
70-79	264	221	83.7	31	14.0					2	0.9	15	6.8	173	78.3	4.22	84.3
80-89	123	89	72.4	4	4.5							2	2.2	83	93.3	4.76	95.1
90-99	37	25	67.6	2	8.0									23	92.0	4.60	92.0
Total :	3717	2300	61.9	725	31.5	1	0.04	3	0.1	35	1.5	177	7.7	1359	59.1	3.31	66.2
Boys(R)	3122	1937	62.0	596	30.8	1	0.1	2	0.1	30	1.6	152	7.9	1156	59.7	3.35	67.0
Boys(P)	463	266	57.5	88	33.1			1	0.4	5	1.9	23	8.7	149	56.0	3.21	64.2
Girls(R)	97	72	74.2	27	37.5							1	1.4	44	61.1	3.11	62.2
Girls(P)	35	25	71.4	14	56.0							1	4.0	10	40.0	2.16	43.2
Total :	3717	2300	61.9	725	31.5	1	0.04	3	0.1	35	1.5	177	7.7	1359	59.1	3.31	66.2

Q.3. Either, (b). A rectangular court 24 yds. long and 16 yds. broad has within it a path of uniform breadth of 2 yds. running around it. Find the area of the path.
5

Q. 3(c) Income-Tax Problem in Arithmetic

Allotted Mark	Average Score	S. D.	C. V.
5	4.4	1.61	37

Students capable of securing

29	29	34	39

on the Full Paper can score

30	50	60	80

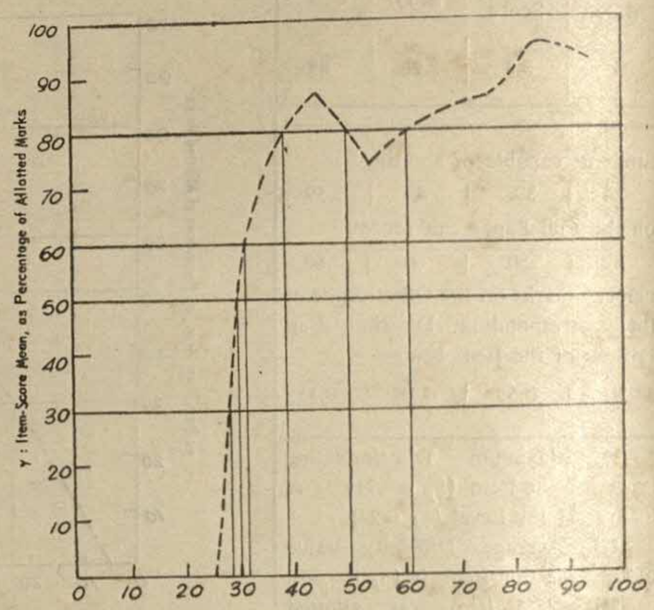
percent marks on the Question-item, the corresponding Discriminating Powers of the Item being

0.90	0.90	0.84	0.67

(I). Maximum Discriminating Power of this Item ($\delta_p = 0.90$) is at a Low Ability Level ($\delta_L = 29$).

(II). Average Difficulty Value of the Question-Item is ($\delta_v = 0.39$).

(III). The item was allotted 5 marks, but it appears to deserve an Optimum of 4 marks only.



Discriminating Graph for Q. 3(c) on Percentage Problem in Arithmetic

TABLE NO. 10

Appendix - B

Showing Performances of Candidates in Mathematics on Question No.3(c)

Marks secured in the range as follows	No. of candidates for the paper	No. of candidates attempting the Item (p.c. to Total)		No. of Candidates Securing Marks as follows: with p.c. to total No. of attempts										Average Marks Secured	
				0		1	2		3		4	5			
		No.	p.c. to Total	No.	p.c.		No.	p.c.	No.	p.c.		No.	p.c.	Actual	p.c. of Max. Marks
0 - 09	72	0	0.0											0.00	0.0
10 - 19	121	1	0.8	1	100.0									0.00	0.0
20 - 29	190	1	0.5	1	100.0									0.00	0.0
30 - 39	759	12	1.6	3	25.0				1	8.3		8	66.7	3.58	71.6
40 - 49	938	24	2.6	3	12.5				1	4.2		20	83.3	4.29	85.8
50 - 59	752	24	3.2	2	8.3		1	4.2	2	8.3		19	78.6	4.29	85.8
60 - 69	461	31	6.7	3	9.7				1	3.2		27	87.1	4.45	89.0
70 - 79	264	38	14.4	1	2.6							37	97.4	4.87	97.4
80 - 89	123	31	25.2	3	9.7				1	3.2		27	87.1	4.45	89.0
90–	37	12	32.4	0	0.0							12	100.0	5.00	100.0
Total:	3717	174	4.7	17	9.8		1	0.6	6	3.4		150	84.3	4.37	87.4
Boys (R)	3122	158	5.2	14	11.1		1	0.6	6	3.7		137	84.6	4.39	87.8
Boys (P)	463	12	2.6	2	16.7							10	83.3	4.16	83.2
Girls (R)	97	4	4.1	1	25.0							3	75.0	3.75	75.0
Girls (P)	35	0	0.0	0	0.0									0.00	0.0
Total	3717	174	4.7	17	9.8		1	0.6	6	3.4		150	84.3	4.37	87.4

Q.3. Or, (c). When the income-tax is 7p. in the rupee, a person has to pay Rs. 31 4 as. more than when the tax was 5p. in the rupee. Find his income. 5

Q. 3(d) An Allegation Problem in Arithmetic

Allotted Mark	Average Score	S. D.	C. V.
5	4.6	1.38	30

Students capable of securing

4	7	9	49

on the Full Paper can score

30	50	60	80

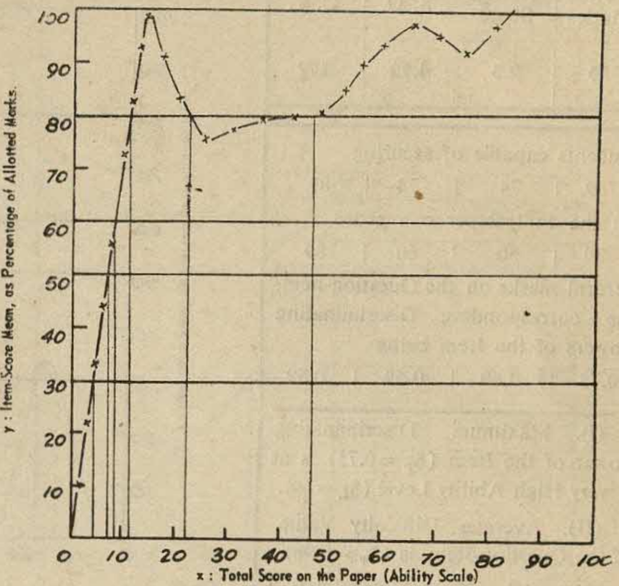
percent marks on the Question-item, the correponding Discriminating Powers of the Item being

0.90	0.90	0.90	0.18

(I). Maximum Discriminating Power of this Item ($\delta_p = 0.90$) is at a very Low Ability Level ($\delta_L = 4$).

(II). Average Difficulty Value of the Question-Item is ($\delta_v = 0.32$).

(III). The item was allotted 5 marks, but it appears to deserve an Optimum of 3 marks only.



Discriminating Graph for Q.3(d) on Alligation Problem in Arithmetic

TABLE NO. 11

Appendix - B

Showing Performances of Candidates in Mathematics on Question No. 3(d).

Marks secured in the range as follows.	No. of candidates for the paper	No. of candidates attempting the Item (p.c. to Total)		No. of Candidates Securing Marks as follows : with p.c. to total No. of attempts.												Average Marks secured	
				0		1		2		3		4		5			
		No.	p.c. to total	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	Actual	p.c. of Max. Marks
0- 09	72	0	0.0													0.00	00.0
10- 19	121	6	5.0									1	16.7	5	83.3	4.83	96.6
20- 29	190	4	2.1	1	25.0									3	75.0	3.75	75.0
30- 39	759	15	2.0	3	20.0							1	6.7	11	73.3	3.93	78.6
40- 49	938	25	2.7	5	20.0							1	4.0	19	76.0	3.96	79.2
50- 59	752	29	3.8	3	10.3							2	6.9	24	82.8	4.41	88.2
60- 69	461	32	6.9	1	3.1									31	96.9	4.84	96.8
70- 79	264	35	13.2	3	8.6							1	2.9	31	88.6	4.54	90.8
80- 89	123	32	26.0											32	100.0	5.00	100.0
90–	37	12	3.2											12	100.0	5.00	100.0
Total :	3717	190	5.1	16	8.4							6	3.2	168	88.4	4.55	91.0
Boys (R)	3122	169	5.4	13	18.0							5	3.1	151	93.2	4.78	95.6
Boys (P)	463	17	3.7	2	11.8							1	5.9	14	82.6	4.38	87.6
Girls (R)	97	4	4.1	1	25.0									3	75.0	3.75	75.0
Girls (P)	35	0	0.0													0.00	00.0
Total	3717	190	5.1	16	8.4							6	3.2	168	88.4	4.55	91.0

Q.3. Or, (b). A person buys 20 srs. of milk at 9 as. 6 p. per seer. How much water must he add to it so that he may gain Re.1 10 as. by selling the mixture at 9 as. per seer ?
5

Q. 4(a) A Time and Distance Problem in Arithmetic

Allotted Mark	Average Score	S. D.	C. V.
10	**2.5**	**4.22**	**172**

Students capable of securing

69	74	74	89

on the Full Paper can score

30	50	60	80

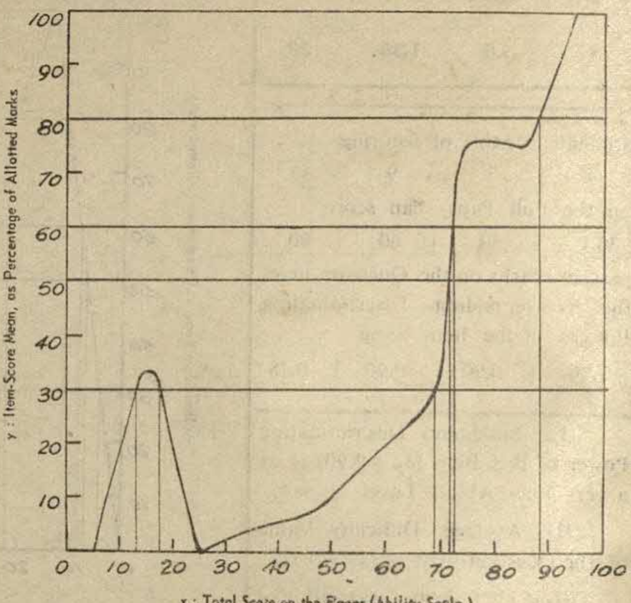
percent marks on the Question-item, the corresponding Discriminating Powers of the Item being

0.75	0.69	0.69	0.59

(I). Maximum Discriminating Power of the Item ($\delta_p = 0.75$) is at a very High Ability Level ($\delta_L = 69$).

(II). Average Difficulty Value of the Question-Item is ($\delta_v = 0.98$).

(III). The item was allotted 10 marks, and it appears to deserve an Optimum of also 10 marks only.



Discriminating Graph for Q.4(a) on Time & Distance Problem in Arithmetic

TABLE NO. 12

Appendix - B

Showing Performances of Candidates in Mathematics on Question No.4(a).

Marks secured in the range as follows	No. of candidates for the Paper	No. of candidates attempting the Item (p.c. to total)		No. of Candidates Securing Marks as follows : with p.c. to total No. of attempts.								Average Marks Secured.	
				0		8		9		10			
		No.	p.c. to Total	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	Actual	p.c. of Max. Marks
0–09	72	1	1.4	1	100.0							0.0	0.0
10–19	121	3	2.5	2	66.7					1	33.3	3.3	33.3
20–29	190	1	0.5	1	100.0							0.0	0.0
30–39	759	19	2.5	18	94.7	1	5.3					0.4	4.0
40–49	938	30	3.3	28	93.4			1	3.3	1	3.3	0.6	6.0
50–59	752	36	4.8	30	83.2			2	5.6	4	11.2	1.6	16.0
60–69	461	20	4.3	15	75.0			1	5.0	4	20.0	2.5	25.0
70–79	264	14	5.3	3	21.3	1	7.1	2	14.2	8	57.4	7.6	76.0
80–89	123	8	6.5	2	25.0					6	75.0	7.5	75.0
90–	37	1	2.7							1	100.0	10.0	100.0
Total :	3717	133	3.6	100	75.2	2	1.5	6	4.6	25	18.8	2.4	24.0
Boys (R)	3122	110	3.5	81	73.6	2	1.8	5	4.6	22	20.0	2.56	25.6
Boys (P)	463	19	4.1	15	79.0			1	5.3	3	15.8	2.05	20.5
Girls (R)	97	3	3.1	–	–								
Girls (P)	35	1	2.9	1	100.0								
Total :	3717	133	3.6	100	75.2	2	1.5	6	4.6	25	18.8	2.46	24.6

Q..4 Either, (a). A train 110 yds. long overtook a person walking along the lines at the rate of 3 miles an hour, and passed him completely in 9 seconds afterwards it overtook another person and passed him in 9 3/8 seconds. At what rate was this second person walking ?

10

Q. 4(c) A Stock and Share Problem in Arithmetic

Allotted Mark	Average Score	S. D.	C. V.
10	**6.8**	**4.44**	**66**

Students capable of securing

39	49	54	64

on the Full Paper can score

30	50	60	80

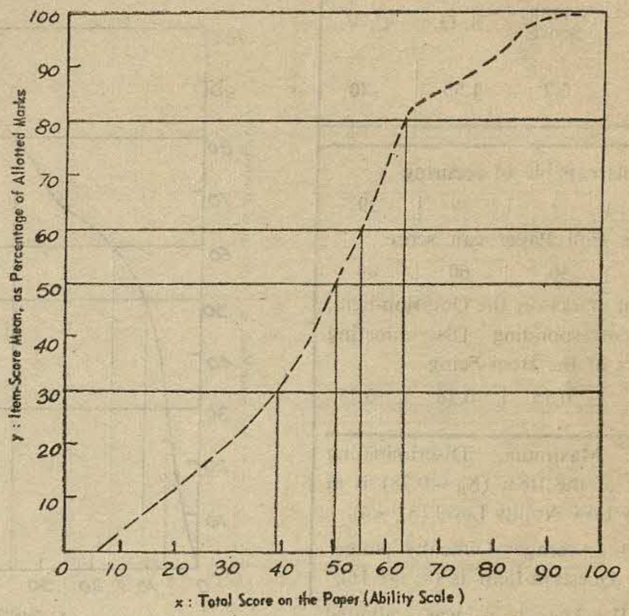
percent marks on the Question-item, the correponding Discriminating Powers of the Item being

0.73	0.69	0.62	0.53

(I). Maximum Discriminating Power of this Item ($\delta_p = 0.73$) is at a Moderate Ability Level ($\delta_L = 39$).

(II). Average Difficulty Value of the Question-Item is ($\delta_v = 0.64$).

(III). The item was allotted 10 marks, but it appears to deserve an Optimum of 7 marks only.



Discriminating Graph for Q. 4(c) on Stock & Share Problem in Arithmetic

TABLE NO. 13

Appendix - B

Showing Performances of Candidates in Mathematics on Question No. 4(c).

Marks secured in the range as follows.	No. of candidates for the Paper.	No. of candidates attempting the Item (p.c. to total)		No. of candidates securing marks as follows : with p.c. to totab No. of attempts.																Average Marks Secured	
				0		1 2 3	4		5	6		7		8		9		10		Actual	p.c. of Max. Marks
				No.	p.c.		No.	p.c.		No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.		
0–09	72	5	6.9	5	100.0															0.0	0.0
10–19	121	11	9.1	10	90.9											1	9.1			0.8	8.0
20–29	190	17	8.9	14	82.3											2	11.8	1	5.9	1.7	17.0
30–39	759	104	13.7	77	74.0		1	1.0						2	1.9	5	4.8	19	18.3	2.4	24.0
40–49	938	186	19.8	109	58.6							1	0.5	5	2.7	29	15.6	42	22.6	3.9	39.0
50–59	752	279	37.1	105	37.6					1	0.4	1	0.4	7	2.5	50	17.9	115	41.2	6.0	60.0
60–69	461	314	58.1	44	14.0					2	0.6	1	0.3	5	1.6	76	24.2	186	59.3	8.3	83.0
70–79	264	231	87.5	23	10.1									2	0.8	53	22.9	153	66.2	8.8	88.0
80–89	123	111	90.2	1	0.9											25	22.5	85	76.6	9.7	97.0
90–	37	36	97.3													4	11.1	32	88.9	9.9	99.0
Total:	3717	1294	34.8	388	30.1		1	0.1		3	0.2	3	0.2	21	1.6	245	18.9	633	48.9	6.8	68.0
Boys (R)	3122	1131	36.2	322	28.3		1	0.1		3	0.3	3	0.3	18	1.6	211	18.7	573	50.7	6.91	69.1
Boys (P)	463	104	22.5	41	39.4									3	2.9	20	19.2	40	38.5	5.81	58.1
Girls (R)	97	50	51.5	20	40.0											13	26.0	17	34.0	5.74	57.4
Girls (P)	35	9	25.7	5	55.9											1	11.1	3	33.0	4.33	43.3
Total:	3717	1294	34.8	388	30.1		1	0.1		3	0.2	3	0.2	21	1.6	245	18.9	633	48.9	6.8	68.0

Q. 4, Or, A person transfers Rs. 8,000 stock from 4 per cent Government Securities at 98 5/8 to 6 per cent Municipal Debentures at 131 5/24. Find the alteration in his income, the usual brokerage (1/8) per cent) being charged on each transaction. 10

Q. 5(a) A Factorisation Problem in Algebra

Allotted Mark	Average Score	S. D.	C. V.
6	**5.2**	**1.55**	**30**

Students capable of securing

4	9	19	39

on the Full Paper can score

30	50	60	80

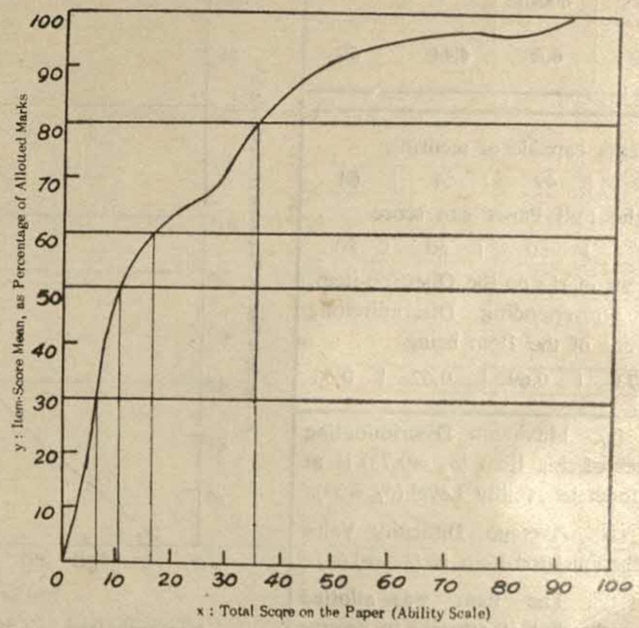
percent marks on the Question-item, the corresponding Discriminating Powers of the Item being

0.78	0.55	0.36	0.25

(I). Maximum Discriminating Power of the Item ($\delta_p = 0.78$) is at a very Low Ability Level ($\delta_L = 4$).

(II). Average Difficulty Value of the Question-Item is ($\delta_v = 0.16$).

(III). The item was allotted 6 marks, but it appears to deserve an Optimum of 2 marks only.



Discriminating Graph for Q.5(a) on Factorisation Problem in Algebra

TABLE NO. 14

Showing Performances of Candidates in Mathematics on Question No. 5(a).

Marks secured in the range as follows	No. of candidates for the Paper	No. of candidates attempting the Item (p.c. to Total)		No. of Candidates Securing Marks as follows : with p.c. to total No. of attempts.										Average Marks Secured	
				0		1		2		3		4			
		No.	p.c. to Total	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	Actual	p.c. of Max. Marks
0–09	72	9	12.5	8	88.9							1	11.1	0.56	11.2
10–19	121	40	33.1	35	87.5							5	12.5	0.63	12.6
20–29	190	71	37.4	58	81.7					2	2.8	11	15.5	0.89	17.8
30–39	759	373	49.1	226	60.6	1	0.3	3	0.8	11	2.9	132	35.4	1.92	38.4
40–49	938	541	57.7	216	39.9	2	0.4	2	0.4	23	4.3	298	55.1	2.94	58.8
50–59	752	480	63.8	134	27.9	2	0.4	1	0.2	20	4.2	323	67.3	3.54	70.8
60–69	461	301	65.3	69	22.9	1	0.3			4	1.3	227	75.4	3.83	76.6
70–79	264	189	71.6	25	13.2					3	1.6	161	85.2	4.32	86.4
80–89	123	82	66.7	1	1.2					2	2.4	79	96.3	4.91	98.2
90–	37	21	56.8	1	4.8							20	95.2	4.76	95.2
Total :	3717	2107	56.7	773	36.7	6	0.3	6	0.3	65	3.1	1257	59.6	3.12	62.4
Boys (R)	3122	1788	57.1	647	36.3	3	0.2	6	0.3	55	3.1	1072	61.1	3.19	63.8
Boys (P)	463	252	54.4	106	42.1	2	0.8			9	3.6	135	53.6	2.84	56.8
Girls (R)	97	53	54.6	13	24.5	1	1.9					39	73.6	3.72	74.4
Girls (P)	35	19	54.3	7	36.8					1	5.7	11	57.9	3.10	62.0
Total :	3717	2107	56.7	773	36.7	6	0.3	6	0.3	65	3.1	1257	59.6	3.12	62.4

Q.5. Either, (a) Factorise : (i) $2x^2 + x - 15$; (ii) $x^4 + 64$

3 · 3

Q. 5(b) An L. C. M. Problem in Algebra

Allotted Mark	Average Score	S. D.	C. V.
5	3.1	2.39	77

Students capable of securing

29	39	44	69

on the Full Paper can score

30	50	60	80

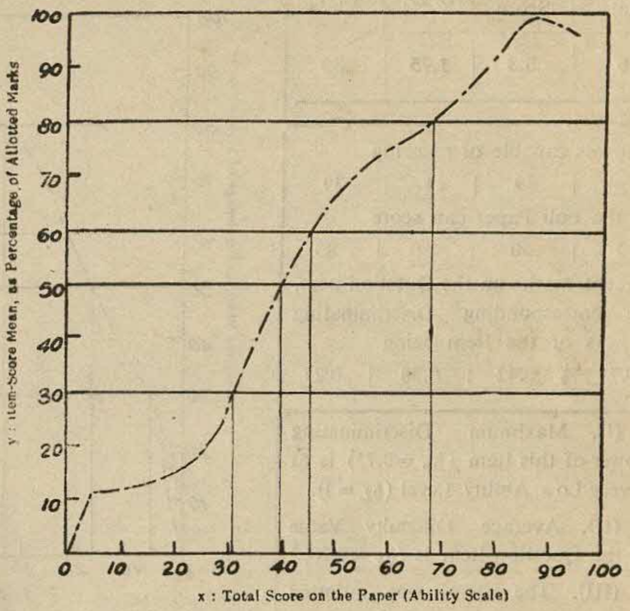
percent marks on the Question-item, the corresponding Discriminating Powers of the Item being

0.69	0.60	0.56	0.39

(I). Maximum Discriminating Power of the Item ($\delta_p = 0.69$) is at a Low Ability Level ($\delta_L = 29$).

(II). Average Difficulty Value of the Question-Item is ($\delta_v = 0.54$).

(III). The item was allotted 5 marks, and it appears to deserve an Optimum of 6 marks.



Discriminating Graph for Q.5(b) on L.C.M. Problem in Algebra

TABLE NO. 15

Appendix - B

Showing Performances of Candidates in Mathematics on Question No. 5(b).

Marks secured in the range as follows.	No. of candidates for the Paper	No. of candidates attempting the Item (p.c. to total)		No. of Candidates Securing Marks as follows : with p.c. to total No. of attempts											Average Marks Secured	
				0		1	2		3		4		5		Actual	p.c. of Max. Marks
		No.	p.c. to Total	No.	p.c.		No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.		
0–09	72	9	12.5	8	88.9								1	11.1	0.56	11.2
10–19	121	40	33.1	35	87.5								5	12.5	0.63	12.6
20–29	190	71	37.4	58	81.7						2	2.8	11	15.5	0.89	17.8
30–39	759	373	49.1	226	60.6		1	0.3	3	0.8	11	2.9	132	35.4	1.92	38.4
40–49	938	541	57.7	216	39.9		2	0.4	2	0.4	23	4.3	298	55.1	2.94	58.8
50–59	752	480	63.8	134	27.9		2	0.4	1	0.2	20	4.2	323	67.3	3.54	70.8
60–69	461	301	65.3	69	22.9		1	0.3			4	1.3	227	75.4	3.83	76.6
70–79	264	189	71.6	25	13.2						3	1.6	161	85.2	4.32	86,4
80–89	123	82	66.7	1	1.2						2	2.4	79	96.3	4,91	98.2
90–	37	21	56.8	1	4.8								20	95.2	4.76	95.2
Total :	3717	2107	56.7	773	36.7		6	0.3	6	0.3	65	3.1	1257	59.6	3.12	62.4
Boys (R)	3122	1783	57.1	647	36.3		3	0.2	6	0.3	55	3.1	1072	61.1	3.19	63.8
Boys (P)	463	252	54.4	106	42.1		2	0.8			9	3.6	135	53.6	2.84	56.8
Girls (R)	97	53	54.6	13	24.5		1	1.9					39	73.6	3.72	74.4
Girls (P)	35	19	54.3	7	36.8						1	5.7	11	57.9	3.10	62.0
Total	3717	2107	56.7	773	36.7		6	0.3	6	0.3	65	3.1	1257	59.6	3.12	62.4

Q.5. Either, (b) Find the L.C.M. of $x^2(x^2-4)$ and $x^4+2x^3-8x^2$

5

Q. 5(c) An Identity (Substitution) Problem in Algebra

Allotted Mark	Average Score	S. D.	C. V.
6	5.3	1.75	33

Students capable of securing

4	19	24	39

on the Full Paper can score

30	50	60	80

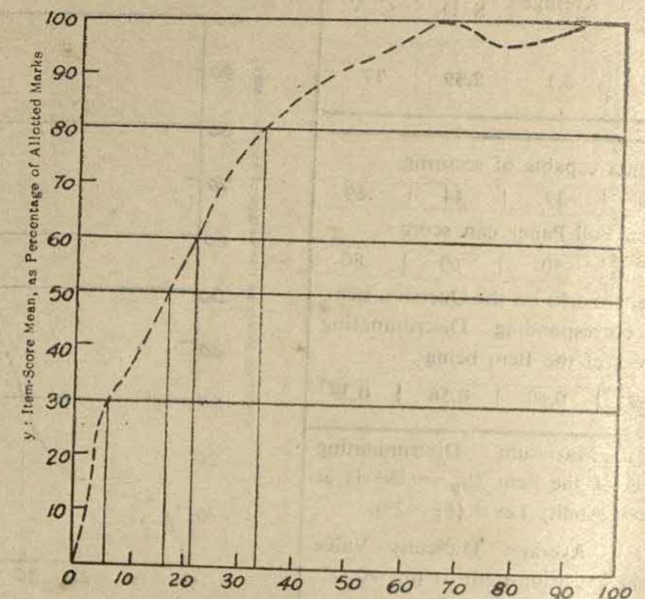
percent marks on the Question-item, the corresponding Discriminating Powers of the Item being

0.75	0.42	0.38	0.27

(I). Maximum Discriminating Power of this Item ($\delta_p = 0.75$) is at a very Low Ability Level ($\delta_L = 4$).

(II). Average Difficulty Value of the Question-Item is ($\delta_v = 0.20$).

(III). The item was allotted 6 marks, but it appears to deserve an Optimum of 2 marks only.



Discriminating Graph for Q.5(c) on Identity (Substitution) Problem in Algebra

TABLE NO. 16

Appendix - B

Showing Performances of Candidates in Mathematics on Question No. 5(c).

Marks secured in the range as follows	No. of candidates for the Paper	No. of candidates attempting the Item (p.c. to total)		No. of Candidates Securing Marks as follows : with p.c. to total No. of attempts.														Average Marks Secured	
				0		1		2	3		4		5		6				
		No.	p.c. to total	No.	p.c.	No.	p.c.		No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.		Actual	p.c. of Max. Marks
0–09	72	3	4.2	2	66.7								1	33.3				1.67	27.8
10–19	121	19	15.7	9	47.3				1	5.3			5	26.3	4	21.0		2.74	45.7
20–29	190	29	15.3	8	27.6				1	3.4	1	3.4	3	10.3	16	55.2		4.07	67.8
30–39	759	131	17.3	22	16.8				5	3.8			11	8.4	93	71.0		4.79	79.8
40–49	938	193	20.6	17	8.8	1	0.5		2	1.0	2	1.0	17	8.8	154	79.8		5.31	88.5
50–59	752	165	21.9	9	5.5								13	7.9	143	86.6		5.59	93.2
60–69	461	115	24.9	1	0.9								6	5.2	108	93.9		5.90	98.3
70–79	264	71	26.9	3	4.2								3	4.2	65	91.6		5.70	95.0
80–89	123	41	33.3										1	2.4	40	97.6		5.98	99.7
90–	37	15	40.5												15	100.0		6.00	100.0
Total:	3717	782	21.0	71	9.1	1	0.1		9	1.2	3	0.4	60	7.7	638	81.6		5.33	88.8
Boys (R)	3122	672	21.5	57	8.5	1	0.1		9	1.3	1	0.1	49	7.3	555	82.6		5.37	89.5
Boys (P)	463	71	15.3	9	12.7						2	2.8	9	12.7	51	71.8		5.06	84.3
Girls (R)	97	33	34.0	4	12.1								2	6.1	27	81.8		5.21	86.8
Girls (P)	35	6	17.1	1	16.7										5	83.3		5.00	83.3
Total :	3717	782	21.0	71	9.1	1	0.1		9	1.2	3	0.4	60	7.7	638	81.6		5.33	88.8

Q.5. Or, (c) Find the value of $xy + yz + zx$, when $x + y + z = 9$ and $x^2 + y^2 + z^2 = 31$.

6

Q· 5(d) An Equation Problem in Algebra

Allotted Mark	Average Score	S. D.	C. V.
5	2.6	2.48	97

Students capable of securing

34	54	69	79

on the Full Paper can score

30	50	60	80

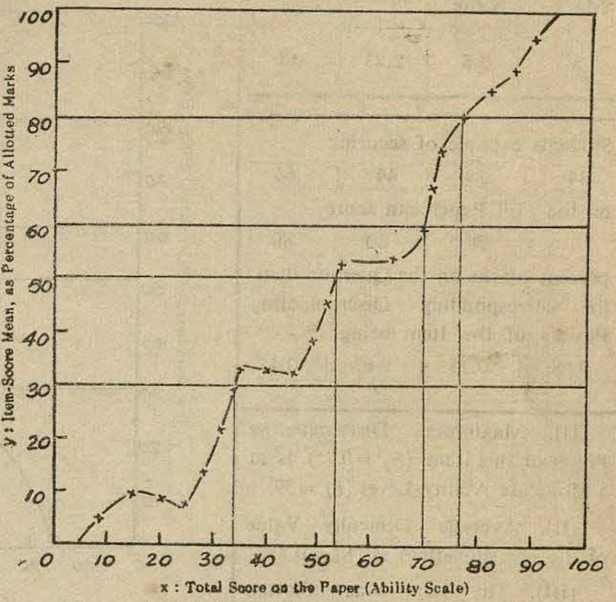
percent marks on the Question-item, the corresponding Discriminating Powers of the Item being

0.43	0.34	0.49	0.48

(I). Maximum Discriminating Power of the Item ($\delta_p = 0.49$) is at a High Ability Level ($\delta_L = 69$).

(II). Average Difficulty Value of the Question-Item is ($\delta_v = 0.65$).

(III). The item was allotted 5 marks, but it appears to deserve an Optimum of 7 marks.



Discriminating Graph for Q.5(d) on Equation Problem in Algebra

Appendix - B

TABLE NO. 17

Showing Performances of Candidates in Mathematics on Question No. 5(d).

Marks secured in the range as follows.	No. of candidates for the Paper	No. of candidates attempting the Item (p.c. to total)		No. of Candidates Securing Marks as follows : with p.c. to total No. of attempts.										Average Marks Secured	
				0		2		3		4		5			
		No.	p.c. to total	No.	p.c.	No.	p.c.	No.	pc	No.	p.c.	No.	p.c.	Actual	p.c. of Max. Marks
0–09	72	2	2.8	2	100.0									0.00	00.0
10–19	121	11	9.1	10	90.9							1	9.1	0.45	9.0
20–29	190	14	7.4	13	92.8							1	7.2	0.36	7.2
30–39	759	59	7.8	39	66.1					3	5.1	17	28.8	1.64	32.8
40–49	938	114	12.2	77	67.5	1	0.9	1	0.9	2	1.8	33	28.9	1.56	31.2
50–59	752	135	18.0	63	46.7					2	1.5	70	51.9	2.65	53.0
60–69	461	94	20.4	44	46.8					1	1.1	49	52.9	2.65	53.0
70–79	264	70	26.5	16	22.8					4	5.7	50	71.4	3.80	76.0
80–89	123	41	33.3	5	12.2							36	87.8	4.39	87.8
90–	37	15	40.5									15	100.0	5.00	100.0
Total :	3717	555	14.9	269	48.5	1	0.2	1	0.2	12	2.2	272	49.0	2.55	51.0
Boys (R)	3122	474	15.2	221	46.6	1	0.2	1	0.2	9	1.9	242	51.1	2.64	52.8
Boys (P)	463	53	11.5	31	58.5					2	3.8	20	37.7	2.04	40.8
Girls (R)	97	25	25.8	14	56.0					1	4.0	10	40.0	2.16	43.2
Girls (P)	35	3	8.6	3	100.0										
Total :	3717	555	14.9	269	48.5	1	0.2	1	0.2	12	2.2	272	49.0	2.55	51.0

Q.5. Or, (d). Solve : $(a/bx) - (b/ax) = a^2 - b^2$

6

Q. 6(a) A Square Root Problem in Algebra

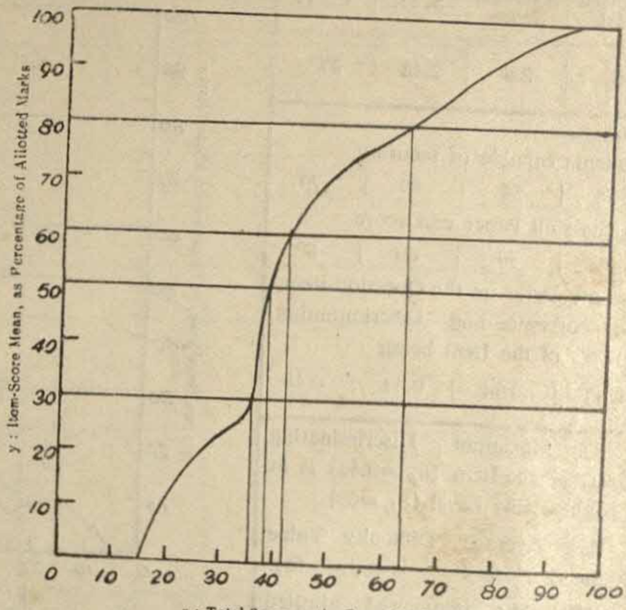
Allotted Mark	Average Score	S. D.	C. V.
5	3.6	2.21	61

Students capable of securing			
34	39	44	64
on the Full Paper can score			
30	50	60	80
percent marks on the Question-item, the corresponding Discriminating Powers of the Item being			
0.68	0.75	0.67	0.45

(I). Maximum Discriminating Power of this Item ($\delta_p = 0.75$) is at a Moderate Ability Level ($\delta_L = 39$).

(II). Average Difficulty Value of the Question-Item is ($\delta_v = 0.85$).

(III). The item was allotted 5 marks, but it appears to deserve an Optimum of 9 marks.



Discriminating Graph for Q.6(a) on Square-root Problem in Algebre

TABLE NO. 18

Showing Performances of Candidates in Mathematics on Question No. 6(a)

Appendix - B

Marks secured in the range as follows.	No. of candidates for the Paper	No. of candidates attempting the Item (p.c. to total)		No. of Candidates Securing Marks as follows : with p.c. to total No. of attempts.										Average Marks Secured	
				0		1	2	3	4		5				
		No.	p.c. to total	No.	p.c.				No.	p.c.	No.	p.c.		Actual	p.c. of Max Marks
0–09	72	0	0.0											0.00	00.0
10–19	121	3	2.5	3	100.0									0.00	00.0
20–29	190	5	2.6	4	80.0						1	20.0		1.00	20.0
30–39	759	18	2.4	13	72.2						5	27.8		1.39	27.8
40–49	938	52	5.5	17	32.7				2	3.8	33	63.5		3.33	66.6
50–59	752	45	6.0	11	24.4						34	75.6		3.78	75.6
60–69	461	38	8.2	7	18.4				2	5.3	29	76.3		4.03	80.6
70–79	264	29	11.0	8	10.3						26	89.7		4.46	89.6
80–89	123	22	17.9	1	4.6						21	95.4		4.77	95.4
90–	37	6	16.2								6	100.0		5.00	100.0
Total :	3717	218	5.9	59	27.1				4	1.8	155	71.1		3.63	72.6
Boys (R)	3122	194	6.2	52	26.8				4	2.1	138	71.1		3.64	72.8
Boys (P)	463	16	3.5	6	37.5						10	62.5		3.12	62.4
Girls (R)	97	6	6.2	1	16.7						5	83.3		4.17	83.4
Girls (P)	35	2	5.7								2	100.0		5.00	100.0
Total :	3717	218	5.9	59	27.1				4	1.8	155	71.1		3.63	72.6

Q.6. Either, (a). Find the square root of $x^4 - 2x^3 + 11x^2 - 10x + 25$

Q. 6(b) A Ratio and Proportion Problem in Algebra

Allotted Mark	Average Score	S. D.	C. V.
5	1.3	2.19	169

Students capable of securing

79	84	89	94

on the Full Paper can score

30	50	60	80

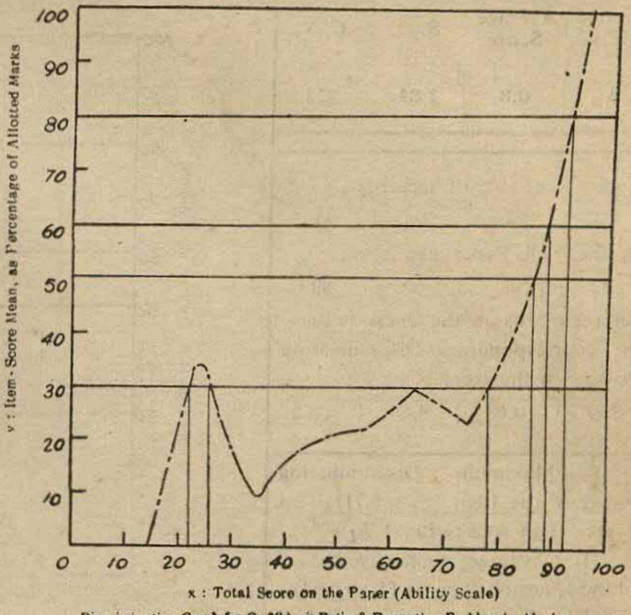
percent marks on the Question-item, the correponding Discriminating Powers of the Item being

0.62	0.64	0.66	0.68

(I). Maximum Discriminating Power of this Item ($\delta_p = 0.68$) is at a very High Ability Level ($\delta_L = 94$).

(II). Average Difficulty Value of the Question-Item is ($\delta_v = 0.97$).

(III). The item was allotted 5 marks, but it appears to deserve an Optimum of 10 marks.



Discriminating Graph for Q. 6(b) on Ratio & Proportion Problem in Algebra

TABLE NO. 19

Appendix - B

Showing Performances of Candidates in Mathematics on Question No. 6(b).

Marks secured in the range as follows	No. of candidates for the Paper	No. of candidates attempting the Item (p.c. to total)		No. of Candidates Securing Marks as follows : with p.c. to total No. of attempts.									Average Marks Secured	
				0		1	2	3		4	5			
		No.	p.c. to total	No.	p.c.			No.	p.c.		No.	p.c.	Actual	p.c. of Max. Marks
0–09	72	2	2.8	2	100.0								0.00	00.0
10–19	121	4	3.3	4	100.0								0.00	00.0
20–29	190	3	1.6	2	66.7						1	33.3	1.67	33.4
30–39	759	21	2.8	19	90.5						2	9.5	0.48	9.6
40–49	938	24	2.6	19	79.2			1	4.2		4	16.7	0.96	19.2
50–59	752	32	4.3	25	78.1						7	21.9	1.09	21.8
60–69	461	17	3.7	12	70.6						5	29.4	1.47	29.4
70–79	264	13	4.9	10	76.9						3	23.1	1.15	23.0
80–89	123	11	8,9	6	54.6						5	45.4	2.27	45.4
90–	37	7	18.9								7	100.0	5.00	100.0
Total :	3717	134	3.6	99	73.9			1	0.7		34	25.4	1.29	25.8
Boys (R)	3122	110	3.5	80	72.7						30	27.3	1.36	27.2
Boys (P)	463	20	4.3	17	85.0			1	5.0		2	10.0	0.70	14.0
Girls (R)	97	4	4.1	2	50.0						2	50.0	2.50	50.0
Girls (P)	35													
Total	3717	134	3.6	99	73.9			1	0.7		34	25.4	1.29	25.8

Q.6. Either, (b). If $\frac{ay - bx}{c} = \frac{cx - az}{b} = \frac{bz - cy}{c}$, prove that $\frac{x}{a} = \frac{y}{b} = \frac{z}{c}$

5

Q. 6(c) A Cyclic Factorization Problem in Algebra

Allotted Mark	Average Score	S. D.	C. V.
5	**0.8**	**1.84**	222

Students capable of securing

74	84	94	94

on the Full Paper can score

30	50	60	80

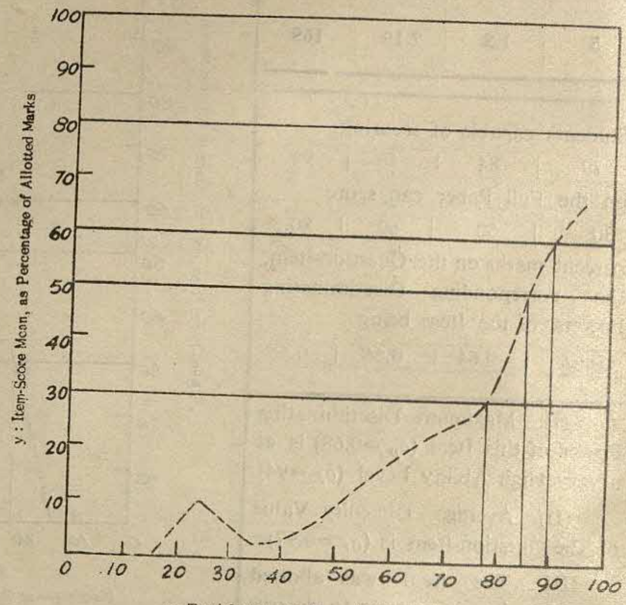
percent marks on the Question-item, the corresponding Discriminating Powers of the Item being

0.71	0.68	0.65	0.65

(I). Maximum Discriminating Power of the Item ($\delta_p = 0.71$) is at a very High Ability Level ($\delta_L = 74$).

(II). Average Difficulty Value of the Question-Item is ($\delta_v = 0.94$).

(III). The item was allotted 5 marks, but it appears to deserve an Optimum of 10 marks only.



x : Total Score on the Paper (Ability Scale)

Discriminating Graph for Q.6(c) on Cyclic Factorization Problem in Algebra

TABLE NO. 20

Showing Performances of Candidates in Mathematics on Question No. 6(c)

Appendix - B

Marks secured in the range as follows	No. of candidates for the Paper	No of candidates attempting the Item (p.c. to Total)		No. of Candidates Securing Marks as follows : with p.c. to total No. of attempts.												Average Marks Secured	
				0		1		2		3		4		5			
		No.	p.c. to total	No.	p.c.	No.	p.c.	No.	P.c.	No.	P.c.	No.	p.c.	No.	P.c.	Actual	p.c. of Max. Marks
0–09	72	7	9.7	7	100.0											0.00	00.0
10–19	121	14	11.6	14	100.0											0.00	00.0
20–29	190	26	13.7	23	88.5					1	3.8			2	7.7	0.50	10.0
30–39	759	121	15.9	117	96.7	1	0.8			1	0.8			2	1.7	0.12	2.4
40–49	938	193	20.6	182	94.3	1	0.5					1	0.5	9	4.7	0.26	5.2
50–59	752	191	25.4	162	84.8			1	0.5			3	1.6	25	13.1	0.73	14.6
60–69	461	132	28.6	102	77.3			1	0.8			2	1.5	27	20.4	1.10	22.0
70–79	264	111	42.0	82	73.9							2	1.8	27	24.3	1.29	25.8
80–89	123	58	47.2	30	51.7							1	1.7	27	46.6	2.40	48.0
90–	37	27	73.0	9	33.3							1	3.7	17	63.0	3.30	66.0
Total	3717	880	23.7	728	82.7	2	0.2	2	0.2	2	0.2	10	1.1	136	15.5	0.83	16.6
Boys (R)	3122	729	23.4	597	81.9	2	0.3	2	0.3	2	0.3	7	1.0	119	16.3	0.87	17.4
Boys (P)	463	108	23.3	99	91.7							1	0.9	8	7.4	0.40	8.0
Girls (R)	97	31	32.0	22	71.0									9	29.0	1.45	29.0
Girls (P)	35	12	34.3	10	83.3							2	16.7			0.67	13.4
Total	3717	880	23.7	728	82.7	2	0.2	2	0.2	2	0.2	10	1.1	136	15.5	0.83	16.6

Q.6. Or, (c). If $a + b + c - 0$, prove that $a(b-c)^3 + b(c-a)^3 + c(a-b)^3 - 0$

5

Q. 6(d) Some Equation Problem in Algebra

Allotted Mark	Average Score	S. D.	C. V.
5	3.9	1.96	50

Students capable of securing

29	34	39	54

on the Full Paper can score

30	50	60	80

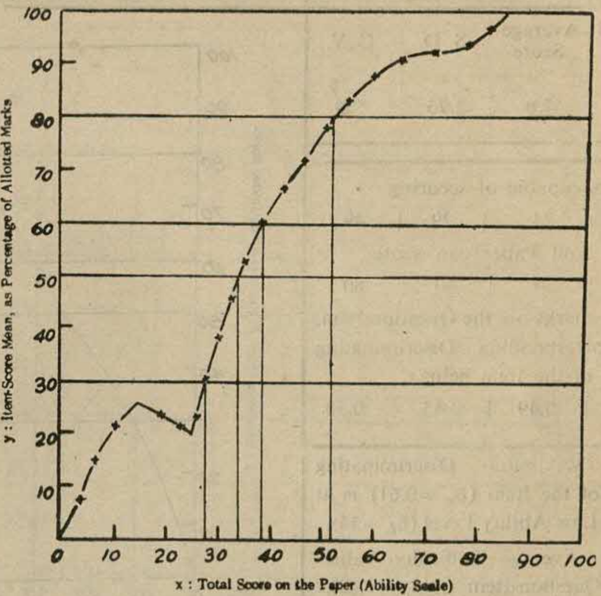
percent marks on the Question-item, the correponding Discriminating Powers of the Item being

0.65	0.59	0.52	0.41

(I). Maximum Discriminating Power of this Item ($\delta_p = 0.65$) is at a Low Ability Level ($\delta_L = 29$).

(II). Average Difficulty Value of the Question-Item is ($\delta_v = 0.46$).

(III). The item was allotted 5 marks, but it appears to deserve an Optimum of 5 marks only.



Discriminating Graph for Q. 6(d) on Equation Problem in Algebra

TABLE NO. 21

Appendix - B

Showing Performances of Candidates in Mathematics on Question No. 6(d)

Marks secured in the range as follows.	No. of candidates for the Paper	No. of candidates attempting the Item (p.c. to total)		No. of Candidates Securing Marks as follows : with p.c. to total No. of attempts.												Average Marks Secured	
				0		1		2		3		4		5			
		No.	p.c. to total	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	Actual	p.c. of Max. Marks
0–09	72	5	6.9	4	80.0			1	20.0							0.40	8.0
10–19	121	14	11.6	10	71.4					1	7.1			3	21.4	1.28	25.6
20–29	190	30	15.8	24	80.0									6	20.0	1.00	20.0
30–39	759	199	26.2	87	43.7					4	2.0	18	9.0	90	45.2	2.68	53.6
40–49	938	401	42.8	119	29.7					6	1.5	23	5.7	253	63.1	3.43	68.6
50–59	752	460	61.2	70	15.2			1	0.2	2	0.4	28	6.1	359	78.0	4.16	83.2
60–69	461	344	74.6	22	6.4			1	0.3	4	1.2	20	5.8	297	86.3	4.50	91.8
70–79	264	224	84.8	15	6.7					2	0.9	13	5.8	194	86.6	4.59	91.8
80–89	123	99	80.5	1	1.0					1	1.0	1	1.0	96	97.0	4.92	98.4
90–	37	30	81.1									2	6.7	28	93.3	4.93	98.6
Total	3717	1806	48.6	352	19.5			3	0.2	20	1.1	105	5.8	1326	73.4	3.94	78.8
Boys (R)	3122	1555	49.8	292	18.8			3	0.2	19	1.2	86	5.5	1155	74.3	3.98	79.6
Boys (P)	463	182	39.3	48	26.4					1	0.6	15	8.2	118	64.8	3.59	71.8
Girls (R)	97	60	61.9	10	16.7							4	6.7	46	76.7	4.10	82.0
Girls (P)	35	9	25.7	2	22.2									7	77.8	3.89	77.8
Total	3717	1806	48.6	352	19.5			3	0.2	20	1.1	105	5.8	1326	73.4	3.94	78.8

Q.6, Or, (d). A number consists of two digits, sum of digits being 5. If 9 be added to the number, the digits are reversed. Find the number.

5

Q. 7 An Graph Drawing Problem in Algebra

Allotted Mark	Average Score	S. D.	C. V.
9	7.0	2.75	39

Students capable of securing

14	24	29	49

on the Full Paper can score

30	50	60	80

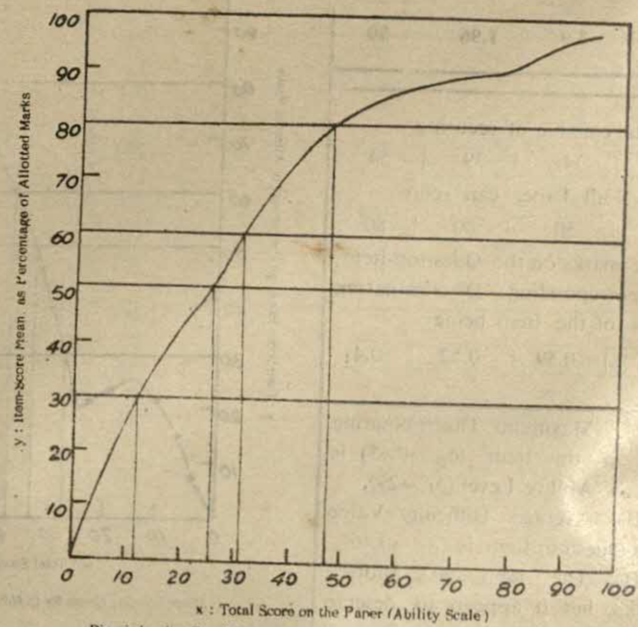
percent marks on the Question-item, the corresponding Discriminating Powers of the Item being

0.61	0.49	0.45	0.30

(I). Maximum Discriminating Power of the Item ($\delta_p = 0.61$) is at a very Low Ability Level ($\delta_L = 14$).

(II). Average Difficulty Value of the Question-Item is ($\delta_v = 0.29$).

(III). The item was allotted 9 marks, but it appears to deserve an Optimum of 3 marks only.



Discriminating Graph for Q. 7 on Graph Drawing Problem in Algebra

Appendix - B

TABLE NO. 22

Showing Performances of Candidates in Mathematics on Question No. 7.

Marks secured in the range as follows	No. of candidates for the Paper	No. of candidates attempting the Item (p.c. to total)		No. of Candidates Securing Marks as follows : with p.c. to total No. of attempts.																				Average Marks Secured	
				0		1		2		3		4		5		6		7		8		9			
		No.	p.c. to Total	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	Actual	p.c. of Max Marks
0–09	72	25	34.7	18	72.0			1	4.0	2	8.0	2	8.0							1	4.0	1	4.0	1.32	14.7
10–19	121	84	69.4	35	41.7	1	1.2	1	1.2	5	6.0	19	22.6			7	8.3	5	6.0	9	10.7	2	2.4	3.11	34.6
20–29	190	152	80.0	44	28.9					14	9.2	32	21.1			4	2.6	10	6.8	27	17.8	21	13.8	4.40	48.9
30–39	759	669	88.1	71	10.6			6	0.9	42	6.3	144	21.5	7	1.0	25	3.7	56	8.4	114	17.0	204	30.5	6.04	67.1
40–49	938	882	94.0	44	5.0			6	0.7	41	4.6	128	14.5	4	0.5	20	2.3	92	10.4	128	14.5	419	41.5	7.06	78.4
50–59	752	720	95.7	19	2.6					26	3.6	74	10.3	4	0.6	11	1.5	59	8.2	124	17.2	403	56.0	7.63	84.8
60–69	461	456	98.9	8	1.8					10	2.2	34	7.5	2	0.4	5	1.1	41	9.0	75	16.4	281	61.6	7.94	88.2
70–79	264	261	98.9					2	0.8	4	1.5	17	6.5	4	1.5	2	0.8	21	8.0	48	18.4	163	62.4	8.10	90.0
80–89	123	122	99.2	1	0.8							4	3.3					9	7.4	14	11.5	94	77.0	8.50	94.0
90–	37	37	100.0													1	2.7	3	8.1	1	2.7	32	86.5	8.73	97.0
Total	3717	3408	91.7	240	7.0	1	0.3	16	0.5	144	4.2	454	13.3	21	0.6	75	2.2	296	8.7	541	8.7	1620	47.5	6.99	77.7
Boys(F)	3122	2879	92.2	198	6.9	1	0.3	13	0.5	111	3.9	370	12.9	17	0.6	62	2.1	241	8.4	458	15.9	1408	48.9	7.06	78.4
Boys(P)	463	411	88.8	30	7.3			3	0.7	27	6.6	65	15.8	4	1.0	11	2.7	44	10.7	67	16.3	160	38.9	6.61	73.4
Girls(F)	97	89	91.8	7	7.9					4	4.5	16	18.0			1	1.1	10	11.2	9	10.1	42	47.2	6.76	75.1
Girls(P)	35	29	82.9	5	17.2					2	6.9	3	10.3			1	3.5	1	3.5	7	24.5	10	34.5	6.10	67.8
Total	3717	3408	91.7	240	7.0	1	0.3	16	0.5	144	4.2	454	13.3	21	0.6	75	2.2	296	8.7	541	15.9	1620	47.5	6.99	77.7

Q.7. Draw the graphs of $x + y = 2$ and $x = y$. Measure their angle of intersection, and determine the point where they meet.
9

Q. 8(a) A Theorem on the Sides of a Triangle ·

Allotted Mark	Average Score	S. D.	C. V.
6	**5.0**	**1.82**	**37**

Students capable of securing

9	19	24	39

on the Full Paper can score

30	50	60	80

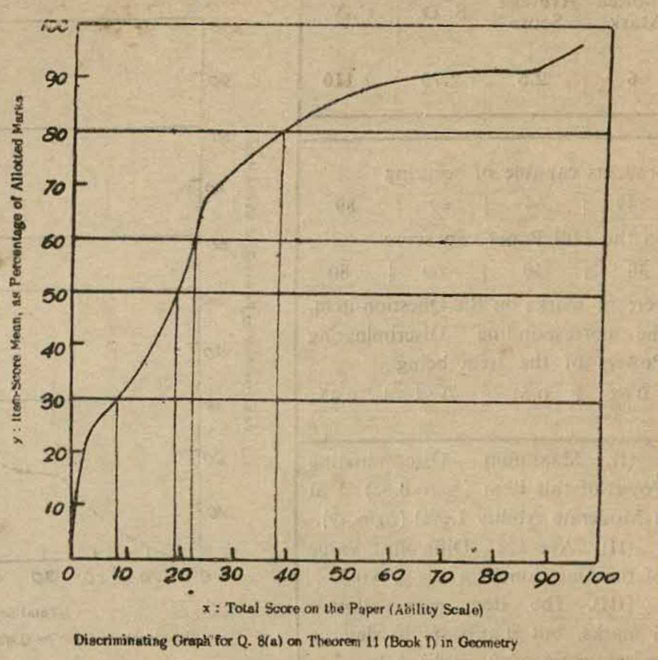
percent marks on the Question-item, the corresponding Discriminating Powers of the Item being

0.53	0.47	0.41	0.27

(I). Maximum Discriminating Power of the Item ($\delta_p = 0.53$) is at a very Low Ability Level ($\delta_L = 9$).

(II). Average Difficulty Value of the Question-Item is ($\delta_v = 0.19$).

(III). The item was allotted 6 marks, and it appears to deserve an Optimum of 2 marks only.



Discriminating Graph for Q. 8(a) on Theorem 11 (Book I) in Geometry

Appendix - B

TABLE NO. 23

Showing Performances of Candidates in Mathematics on Question No. 8(a).

Marks secured in the range as follows	No. of candidates for the Paper	No. of candidates attempting the Item (p.c. to total)		No. of Candidates Securing Marks as follows: with p.c. to total No. of attempts.														Average Marks Secured	
				0		1		2		3		4		5		6			
		No.	p.c. to total	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	Actual	p.c. of Max. Marks
0–09	72	32	44.4	22	68.8					1	3.1	4	12.5	1	3.1	4	12.5	1.50	25.0
10–19	121	100	82.6	55	55.0			2	2.0	4	4.0	4	4.0	18	18.0	17	17.0	2.24	37.3
20–29	190	156	82.1	35	22.4			3	1.9	7	4.5	13	8.3	33	21.2	65	41.7	4.08	67.7
30–39	759	673	88.7	98	14.6	1	0.1	5	0.7	21	3.1	40	5.9	158	23.5	350	52.0	4.64	77.3
40–49	938	848	90.4	70	8.3			4	0.5	10	1.2	65	7.7	191	22.5	508	59.9	5.07	84.5
50–59	752	685	91.1	36	5.3			4	0.6	7	1.0	40	5.8	155	22.6	443	64.8	5.29	88.2
60–69	461	434	94.1	15	3.5			1	0.2	5	1.2	21	4.8	94	21.7	298	68.7	5.44	90.7
70–79	264	247	93.6	10	4.0							8	3.2	53	21.5	176	71.3	5.48	91.3
80–89	123	114	92.7	4	3.5							3	2.6	28	24.6	79	69.3	5.49	91.5
90–	37	35	94.6											5	14.3	30	85.7	5.88	97.7
Total	3717	3324	89.4	345	10.4	1	0.03	19	0.6	55	1.6	198	6.0	736	22.1	1970	59.3	4.98	82.7
Boys (R)	3122	2791	89.4	278	10.0	1	0.04	12	0.4	48	1.5	149	5.3	614	22.0	1694	60.7	5.01	83.5
Boys (P)	463	417	90.1	55	13.2			6	1.4	11	2.6	45	10.8	92	22.1	208	49.9	4.64	77.3
Girls (R)	97	86	88.7	6	7.0			1	1.2	1	1.2	1	1.2	25	29.1	52	60.5	5.19	86.5
Girls (P)	35	30	85.7	6	20.0							3	10.0	5	16.7	16	53.3	4.45	73.8
Total	3717	3324	89.4	345	10.4	1	0.03	19	0.6	55	1.6	198	6.0	736	22.1	1970	59.3	4.96	82.7

Q.8. Either, (a). Show that any two sides of a triangle are together greater than the third side. 6

Q. 8(b) Some Exercise on a Theorem about Sides of a Triangle

Allotted Mark	Average Score	S. D.	C. V.
6	2.5	2.75	110

Students capable of securing

49	64	69	89

on the Full Paper can score

30	50	60	80

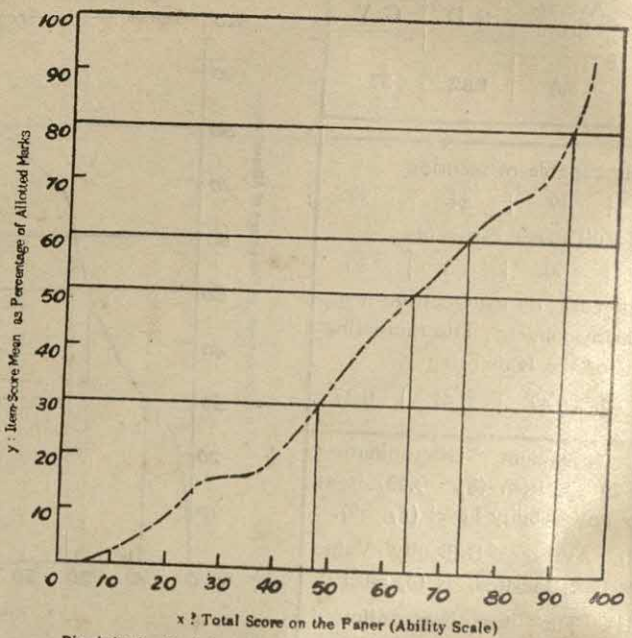
percent marks on the Question-item, the corresponding Discriminating Powers of the Item being

0.68	0.61	0.58	0.45

(I). Maximum Discriminating Power of this Item ($\delta_p = 0.68$) is at a Moderate Ability Level ($\delta_L = 49$).

(II). Average Difficulty Value of the Question-Item is ($\delta_v = 0.82$).

(III). The item was allotted 6 marks, but it appears to deserve an Optimum of 9 marks only.



Discriminating Graph for Q.8(b) - Exercise on Theorem 11 (Book I) in Geometry

TABLE NO. 24

Showing Performances of Candidates in Mathematics on Question No. 8(b)

Appendix - B

Marks secured in the range as follows	No. of candidates for the Paper	No. of candidates attempting the Item (p.c. to total)		No. of Candidates Securing Marks as follows : with p.c. to total No. of attempts.														Average Marks Secured	
				0		1		2		3		4		5		6			
		No.	p.c. to Total	No.	p.c.	No.	p.c.	No.	P.c.	No.	P.c.	No.	P.c.	No.	p.c.	No.	p.c.	Actual	p.c. of Max Marks
0–09	72	13	18.1	13	100.0													0.00	00.0
10–19	121	27	22.9	25	92.6					1	3.7			1	3.7			0.3	4.9
20–29	190	37	19.5	30	81.1					3	8.1			1	2.7	3	8.1	0.9	14.4
30–39	759	190	25.0	152	80.0	1	0.5	1	0.5	3	1.6	7	3.7	8	4.2	18	9.5	1.0	16.5
40–49	938	297	31.7	206	69.4			2	0.7	6	2.0	15	5.1	21	7.1	47	15.8	1.6	26.3
50–59	752	303	40.3	159	52.5			2	0.7	8	2.6	17	5.6	42	13.9	75	24.8	2.5	41.6
60–69	461	268	58.1	114	42.5	1	0.4	4	1.5	5	1.9	17	6.3	35	13.1	92	34.3	3.1	50.9
70–79	264	213	57.9	67	43.7	1	0.7	2	1.3	3	2.0	13	6.5	28	18.3	99	64.6	3.8	62.6
80–89	123	108	87.8	27	25.0			1	0.9	1	0.9	5	4.6	19	17.6	55	50.9	4.2	69.4
90–	37	35	94.6	2	5.7									7	20.0	26	74.3	5.5	91.0
Total	3717	1491	40.1	795	53.3	3	0.2	12	0.8	30	2.0	74	5.0	162	10.9	415	27.8	2.5	41.5
Boys (R)	3122	1266	40.6	660	52.1	2	0.2	8	0.6	26	2.1	59	4.7	142	11.2	369	29.2	2.6	42.8
Boys (P)	463	157	33.9	97	61.8	1	0.7	4	2.6	2	1.3	9	5.7	11	7.0	33	21.0	2.0	32.3
Girls (R)	97	52	53.6	27	51.9					2	3.9	4	7.7	7	13.5	12	23.1	2.5	41.3
Girls (P)	35	16	45.7	11	68.8							2	12.5	2	12.5	1	6.3	1.5	25.0
Total	3717	1491	40.1	795	53.3	3	0.2	12	0.8	30	2.0	74	5.0	162	10.9	415	27.8	2.5	41.5

Q.8. Either, (b). Show that the difference of any two sides of a triangle is less than the third side.

6

Q. 8(c) A Theorem on Properties of Two Triangles

Allotted Mark	Average Score	S. D.	C. V.
6	4.9	1.86	38

Students capable of securing

4 | 9 | 14 | 44

on the Full Paper can score

30 | 50 | 60 | 80

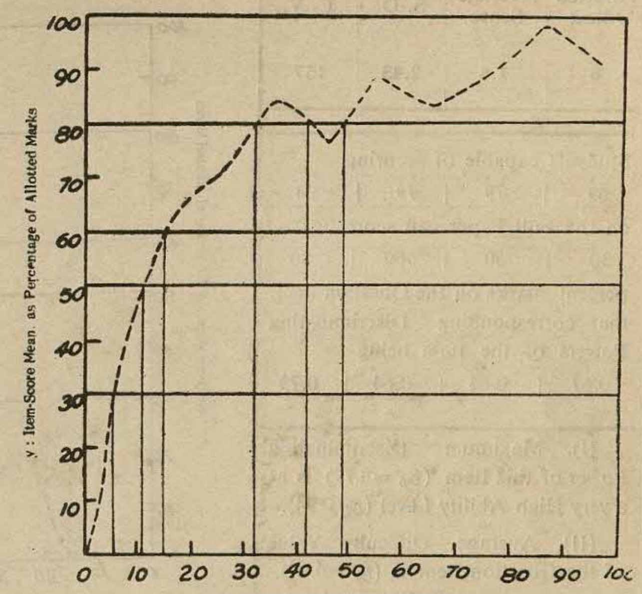
percent marks on the Question-item, the corresponding Discriminating Powers of the Item being

0.80 | 0.60 | 0.48 | 0.19

(I). Maximum Discriminating Power of the Item ($\delta_p = 0.80$) is at a very Low Ability Level ($\delta_L = 4$).

(II). Average Difficulty Value of the Question-Item is ($\delta_p = 0.32$).

(III). The item was allotted 6 marks, but it appears to deserve an Optimum of 3 marks only.



Discriminating Graph for Q. 8(c) on Theorem 26 (Book II) in Geometry

TABLE NO. 25

Appendix - B

Showing Performances of Candidates in Mathematics on Question No. 8(c).

Marks secured in the range as follows.	No. of candidates for the Paper	No. of candidates attempting the Item (p.c. to total)		No. of Candidates Securing Marks as follows : with p.c. to total No. of attempts.														Average Marks Secured	
				0		1		2		3		4		5		6			
		No.	p.c. of total	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	Actual	p.c. of Max. Marks.
0–09	72	4	5.6	3	75,0									1	25.0			1.25	20.8
10–19	121	9	7.4	2	22.2			1	11.1			1	11.1	3	33.3	2	22.2	3.67	61.2
20–29	190	19	10.0	3	15.8			2	10.5			1	5.3	5	26.3	8	42.1	4.26	71.0
30–39	759	62	8.2	5	8.1			1	1.6	1	1.6	3	4.8	15	24.2	37	59.7	5.06	84.3
40–49	938	72	7.7	12	16.7					1	1.4	4	5.6	13	18.1	42	58.3	4.67	77.8
50–59	752	65	8.6	2	3.1					3	4.6	6	9.2	12	18.5	42	64.6	5.31	88.5
60–69	461	25	5.4	2	8.0							4	16.0	4	16.0	15	60.0	5.04	84.0
70–79	264	16	6.1							1	6.2	3	18.8	1	6.2	11	68.8	5.38	89.7
80–89	123	9	7.3											1	11.1	8	88.9	5.89	98.2
90–	37	2	5.4											1	50.0	1	50.0	5.50	91.7
Total:	3717	283	7.6	29	10.2			4	1.4	6	2.1	22	7.8	56	19.8	166	58.7	4.91	81.8
Boys (R)	3122	248	7.9	26	10.5			4	1.6	5	2.0	19	7.7	47	19.0	147	59.3	4.90	81.6
Boys (P)	463	26	5.6	3	11.5					1	3.9	1	3.9	7	26.9	14	53.8	4.85	80.8
Girls (R)	97	7	7.2									1	14.3	1	14.3	5	71.4	5.57	94.5
Girls (P)	35	2	5.7									1	50.0	1	50.0			4.50	75.0
Total	3717	283	7.6	29	10.2			4	1.4	6	2.1	22	7.8	56	19.8	166	58.7	4.91	81.8

Q.8. Or, (c). Prove that the triangles on the same base and between the same parallels are equal in area. 6

Q. 8(d) An Exercise on the Properties of Two Triangles

Allotted Mark	Average Score	S. D.	C. V.
6	1.6	2.43	157

Students capable of securing

69	79	79	94

on the Full Paper can score

30	50	60	80

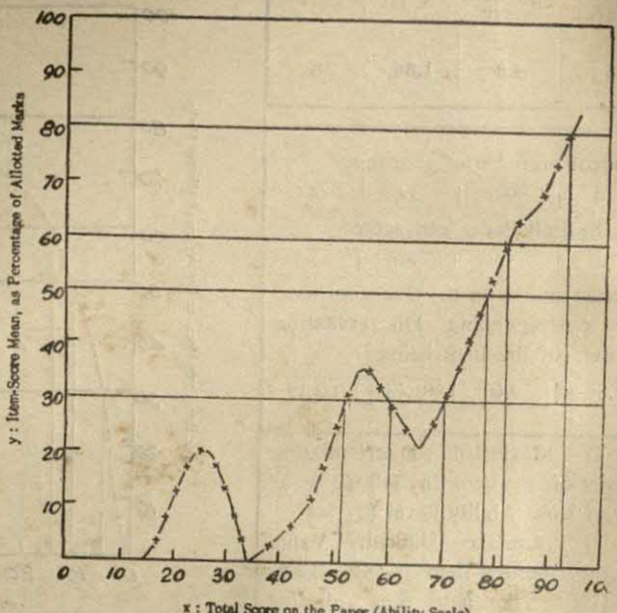
percent marks on the Question-item, the corresponding Discriminating Powers of the Item being

0.67	0.64	0.64	0.79

(I). Maximum Discriminating Power of this Item ($\delta_p = 0.79$) is at a very High Ability Level ($\delta_L = 94$).

(II). Average Difficulty Value of the Question-Item is ($\delta_v = 0.92$).

(III). The item was allotted 6 marks, but it appears to deserve an Optimum of 10 marks.



Discriminating Graph for Q. 8(d) - Exercise on Theorem 26 (Book II) in Geometry

TABLE NO. 26

Appendix - B

Showing Performances of Candidates in Mathematics on Question No. 8(d)

Marks secured in the range as follows	No. of candidates for the Paper	No. of candidates attempting the Item (p.c. to total)		No. of Candidates Securing Marks as follows : with p.c. to total No. of attempts.														Average Marks Secured	
				0		1		2		3		4		5		6			
		No.	p.c. to total	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	Actual	p.c. of Max. Marks
0–09	72	1	1.4	1	100.0													0.00	0.0
10–19	121	5	4.1	5	100.0													0.00	0.0
20–29	190	5	2.6	4	80.0											1	20.0	1.20	20.0
30–39	750	12	1.6	12	100.0													0.00	0.0
40–49	938	19	2.0	17	89.5									1	5.2	1	5.3	0.56	9.7
50–59	752	20	2.7	10	50.0			2	10.0	2	10.0			3	15.0	3	15.0	2.15	35.8
60–69	461	16	3.4	12	75.0									3	18.8	1	6.2	1.31	21.8
70–79	264	12	4.5	6	50.0							2	16.6	1	8.3	3	25.0	2.58	43.0
80–89	123	9	7.3	3	33.3									1	11.1	5	55.6	3.89	64.8
90–	37	2	5.4									1	50.0			1	50.0	5.00	83.3
Total	3717	101	2.7	70	69.2			2	2.0	2	2.0	3	3.0	9	8.9	15	14.8	1.55	25.8
Boys (R)	3122	85	2.7	57	67.1			2	2.4	2	2.4	3	3.5	7	8.2	14	16.5	1.65	27.5
Boys (P)	463	8	1.7	7	87.5									1	12.5			0.62	10.3
Girls (R)	97	6	6.2	5	83.3									1	16.7			0.83	13.8
Girls (P)	35	2	5.7	1	50.0											1	50.0	3.00	50.0
Total	3717	101	2.7	70	69.2			2	2.0	2	2.0	3	3.0	9	8.9	15	14.8	1.55	25.8

Q.8. Or, (d). Show that the areas of the four triangles into which a parallelogram is divided by its diagonals are all equal.

6

Q. 9(a) A Theorem on Properties of Angles of a Triangle

Allotted Mark	Average Score	S. D.	C. V.
7	6.0	2.05	34

Students capable of securing

14	19	24	34

on the Full Paper can score

30	50	60	80

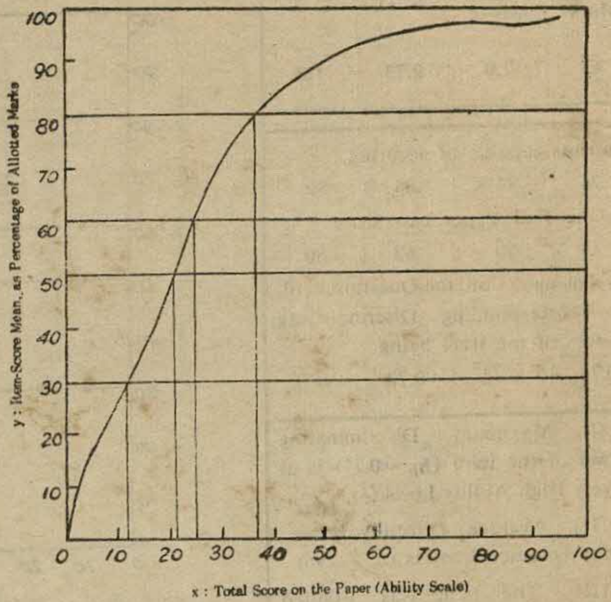
percent marks on the Question-item, the corresponding Discriminating Powers of the Item being

0.61	0.55	0.49	0.37

(I). Maximum Discriminating Power of this Item ($\delta_p = 0.61$) is at a Low Ability Level ($\delta_L = 14$).

(II). Average Difficulty Value of the Question-Item is ($\delta_v = 0.17$).

(III). The item was allotted 7 marks, but it appears to deserve an Optimum of 2 marks only.



Discriminating Graph for Q. 9(a) on Theorem 16 (Book I) in Geometry

TABLE NO. 27

Appendix - B

Showing Performances of Candidates in Mathematics on Question No. 9(a).

Marks secured in the range as follows	No. of candidates for the Paper	No. of candidates attempting the Item (p.c. to Total)		No. of Candidates Securing Marks as follows: with p.c. to total No. of attempts.																Average Marks Secured	
				0		1		2		3		4		5		6		7			
		No.	p.c. to total	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	Actual	p.c. of Max Marks
0–09	72	29	40.3	23	79.5					1	3.4	1	3.4	1	3.4	1	3.4	2	6.9	1.10	15.7
10–19	121	94	77.7	55	58.5							6	6.4	5	5.3	10	10.6	18	19.1	2.50	35.7
20–29	190	163	85.8	52	31.9	1	0.6	1	0.6	2	1.2	8	4.9	10	6.1	21	12.9	68	41.7	4.25	60.7
30–39	759	682	89.9	99	14.5			1	0.1	7	1.0	15	2.2	48	7.0	126	18.4	386	56.5	5.54	79.1
40–49	938	887	94.6	59	6.8			2	0.2	2	0.2	17	1.9	66	7.4	173	19.5	568	64.0	6.11	87.3
50–59	752	730	97.1	23	3.2			1	0.1	1	0.1	10	1.4	27	3.7	116	15.9	552	75.6	6.49	92.7
60–69	461	445	96.5	7	1.6					1	0.2	6	1.4	16	3.6	70	15.7	345	77.5	6.61	94.4
70–79	264	246	93.2									2	0.8	7	2.8	37	15.0	200	81.3	6.77	98.7
80–89	123	115	93.5									1	0.9	6	5.2	18	15.7	90	78.3	6.71	95.9
90–	37	37	100.0											1	2.7	4	10.8	32	86.5	6.84	97.7
Total	3717	3428	92.2	318	9.3	1	0.03	5	0.2	14	0.4	66	1.9	187	5.5	576	16.8	2261	66.0	5.99	85.6
Boys (R)	3122	2880	92.3	245	8.5			4	0.1	9	0.3	56	1.9	144	5.0	474	16.5	1948	67.6	6.06	86.6
Boys (P)	463	432	93.3	66	15.3	1	0.2			3	0.7	8	1.9	42	9.7	61	18.8	231	53.5	5.45	77.9
Girls (R)	97	84	86.6	1	1.2			1	1.2	2	2.4	2	2.4	1	1.2	9	10.7	68	81.0	6.56	93.7
Girls (P)	35	32	91.4	6	18.8											12	37.5	14	43.8	5.81	75.9
Total	3717	3428	92.2	318	9.3	1	0.03	5	0.2	14	0.4	66	1.9	187	5.5	576	16.8	2261	66.0	5.99	85.6

Q.9. Either, (a). Prove that the sum of the three angles of a triangle is equal to two right angles. 7

Q. 9(b) An Exercise on Properties of Triangles in Geometry

Allotted Mark	Average Score	S. D.	C. V.
6	2.0	2.73	136

Students capable of securing

74 | 84 | 84 | 89

on the Full Paper can score

30 | 50 | 60 | 80

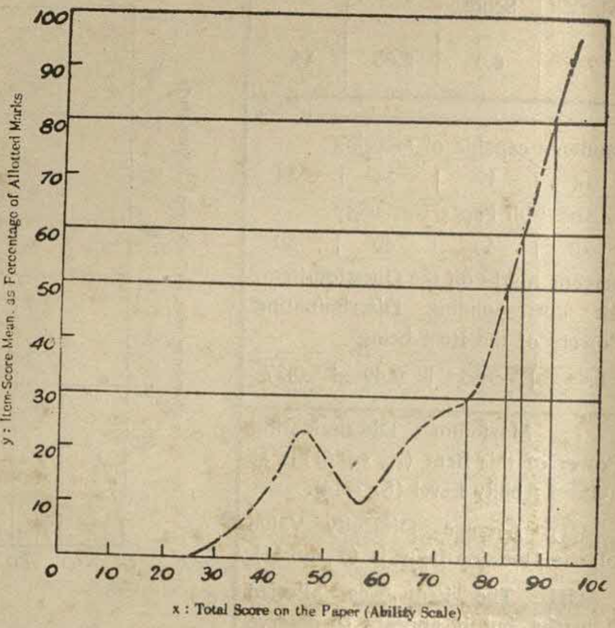
percent marks on the Question-item, the corresponding Discriminating Powers of the Item being

0.74 | 0.72 | 0.72 | 0.70

(I). Maximum Discriminating Power of the Item ($\delta_p = 0.74$) is at a very High Ability Level ($\delta_L = 74$).

(II). Average Difficulty Value of the Question-Item is ($\delta_v = 0.96$).

(III). The item was allotted 6 marks, and it appears to deserve an Optimum of 10 marks.



Discriminating Graph for Q.9(b) - Exercise on Theorem 16 (Book I) in Geometry

TABLE NO. 28

Appendix - B

Showing Performances of Candidates in Mathematics on Question No. 9(b).

Marks secured in the range as follows	No. of candidates for the Paper	No. of candidates attempting the Item (p.c. to Total)		No. of Candidates Securing Marks as follows : with p.c. to total No. of attempts.														Average Marks Secured	
				0		1		2		3		4		5		6			
		No.	p.c. to total	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	Actual	p.c. of Max. Marks
0–09	72	2	2.8	2	100.0													0.0	0.0
10–19	121	3	2.5	3	100.0													0.0	0.0
20–29	190	2	1.1	2	100.0													0.0	0.0
30–39	759	28	3.7	25	89.3					1	3.6			2	7.1			0.5	8.3
40–49	938	52	5.5	38	73.1					2	3.8			6	11.5	6	11.5	1.4	23.3
50–59	752	77	10.2	67	85.9					1	1.3	2	2.6	4	5.1	3	3.8	0.6	10.0
60–69	461	82	17.8	63	76.8					1	1.2			1	1.2	17	20.7	1.3	21.7
70–79	264	99	37.5	67	67.7			1	1.0	2	2.0	2	2.0	5	5.1	22	22.2	1.8	30.0
80–89	123	89	72.4	32	36.0			1	1.1	3	3.4	2	2.2	3	3.4	48	53.9	3.6	60.0
90–	37	36	97.3	1	2.8									3	8.3	32	88.9	5.7	95.0
Total	3717	470	12.6	300	63.8			2	0.4	10	2.1	6	1.3	24	5.1	128	27.2	2.0	33.3
Boys(R)	3122	408	13.1	254	62.3			2	0.5	9	2.2	6	1.5	19	4.7	118	28.9	2.1	35.0
Boys(P)	463	38	8.2	30	79.0									5	13.2	3	7.9	1.1	18.3
Girls(R)	97	21	21.7	13	61.9					1	4.8					7	33.3	2.1	35.0
Girls(P)	35	3	8.6	3	100.0														
Total	3717	470	12.6	300	63.8			2	0.4	10	2.1	6	1.3	24	5.1	128	27.2	2.0	33.3

Q.9. Either, (b). One angle of a triangle is twice the sum of the other two angles. Determine the magnitude of the angle.

6

Q. 9(c) A Theorem on Properties of Circle in Geometry

Allotted Mark	Average Score	S. D.	C. V.
7	4.6	2.77	60

Students capable of securing

29	34	44	69

on the Full Paper can score

30	50	60	80

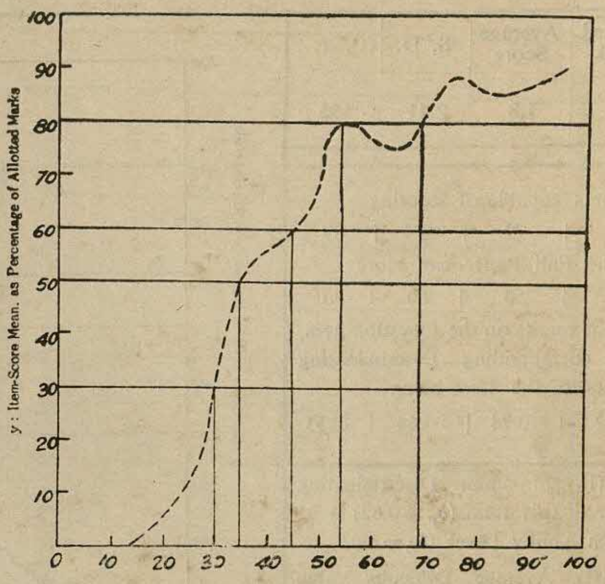
percent marks on the Question-item, the correponding Discriminating Powers of the Item being

0.89	0.75	0.53	0.19

(I). Maximum Discriminating Power of this Item ($\delta_p = 0.89$) is at a Low Ability Level ($\delta_L = 29$).

(II). Average Difficulty Value of the Question-Item is ($\delta_v = 0.67$).

(III). The item was allotted 7 marks, and it appears to deserve an Optimum of also 7 marks.



x : Total Score on the Paper (Ability Scale)

Discriminating Graph for Q. 9(c) on Theorem 32 (Book III) in Geometry

TABLE NO. 29

Appendix - B

Showing Performances of Candidates in Mathematics on Question No. 9(c)

Marks secured in the range as follows	No. of candidates for the Paper	No. of candidates attempting the Item (p.c. to Total)		No. of Candidates Securing Marks as follows : with p.c. to total No. of attempts.																Average Marks Secured	
				0		1		2		3		4		5		6		7			
		No.	p.c. to Total	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	Actual	p.c. of Max Marks
0–09	72	1	1.4	1	100.0															0.00	0.0
10–19	121	4	33.1	4	100.0															0.00	0.0
20–29	190	5	2.6	4	80.0							1	20.0							0.80	11.4
30–39	759	15	2.0	6	40.0			1	6.7							4	26.7	4	26.7	3.60	51.4
40–49	938	16	1.7	4	25.0							2	12.5	4	25.0	3	18.8	3	18.8	4.19	59.8
50–59	752	12	1.6	1	8.3							2	16.7			4	33.3	5	41.7	5.59	79.8
60–69	461	17	3.7	3	17.8									1	5.9	6	35.3	7	41.2	5.29	75.6
70–79	264	18	6.8					1	5.6			1	5.6	1	5.6	5	27.8	10	55.6	6.85	88.1
80–89	123	8	6.5									1	12.5	1	12.5	3	37.5	3	37.5	6.00	85.7
90–	37	0	0.0																		
Total	3717	96	2.6	23	24.0			2	2.1			7	7.3	7	7.3	25	26.0	32	33.3	4.59	65.6
Boys (R)	3122	75	2.4	17	22.7			2	2.7			7	9.3	6	8.0	17	22.7	26	34.7	4.61	65.9
Boys (P)	463	7	1.5	4	57.1											2	28.6	1	14.3	2.71	38.7
Girls (R)	97	12	12.4	1	8.3									1	8.3	6	50.0	4	33.3	5.75	82.1
Girls (P)	35	2	5.7	1	50.0													1	50.0	3.50	50.0
Total	3717	96	2.6	23	24.0			2	2.1			7	7.3	7	7.3	25	26.0	32	33.3	4.59	65.6

Q.9. Or, (c). Prove that one and only one circle posses through three points not lying on a straight line. 7

Q. 9(d) Exercise on Properties of a Circle in Geometry

Allotted Mark	Average Score	S. D.	C. V.
6	1.8	2.41	135

Students capable of securing

59	79	84	89

on the Full Paper can score

30	50	60	80

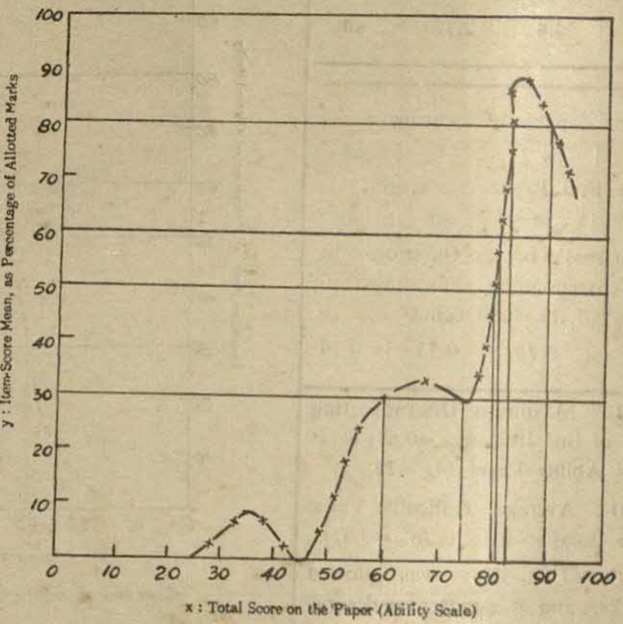
percent marks on the Question-item, the correponding Discriminating Powers of the Item being

0.82	0.74	0.64	0.53

(I). Maximum Discriminating Power of this Item ($\delta_p = 0.82$) is at a High Ability Level ($\delta_L = 59$).

(II). Average Difficulty Value of the Question-Item is ($\delta_v = 0.92$).

(III). The item was allotted 6 marks, but it appears to deserve an Optimum of 10 marks.



Discriminating Graph for Q. 9(d) - Exercise on Theorem 32 (Book III) in Geometry

TABLE NO. 30

Appendix - B

Showing Performances of Candidates in Q.9(d), a rider on Q.9(c), (Theorem 32, Hall & Stevens, Part III).

Marks secured in the range as follows.	No. of candidates for the Paper	Candidates attempting		No. of Candidates securing Marks as follows : with p.c. to total No. of attempts on Q.7.														Average marks Secured	
				0		1		2		3		4		5		6			
		No.	p.c. to Total	No.	p.c.	No.	P.c.	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	Actual	p.c. of Max. Marks
0–09	72	1	1.4	1	100.0													0.00	0.0
10–19	121	0	0.0																
20–29	190	1	0.5	1	100.0													0.00	0.0
30–39	759	6	0.8	5	83.3					1	16.7							0.50	8.3
40–49	938	7	0.8	7	100.0													0.00	0.0
50–59	752	7	0.9	5	71.4									2	28.6			1.43	23.8
60–69	461	7	1.5	4	57.1					1	14.3			1	14.3	1	14.3	2.00	33.3
70–79	264	14	5.3	9	64.2					1	7.1	1	7.1	1	7.1	2	14.3	1.72	28.6
80–89	123	6	4.9									1	16.7	2	33.3	3	50.0	5.33	88.9
90–	37	2	5.4							1	50.0			1	50.0			4.00	66.7
Total	3717	51	1.4	32	62.7					4	7.8	2	3.9	7	13.7	6	11.8	1.78	29.7
Boys (R)	3122	42	1.4	26	61.9					4	9.5	1	2.4	7	16.7	4	9.5	1.79	29.8
Boys (P)	463	1	0.2	1	100.0													0.00	00.0
Girls (R)	97	8	8.3	5	62.5							1	12.5			2	25.0	2.00	33.3
Girls (P)	35	0	0.0																
Total	3717	51	1.4	32	62.7					4	7.8	2	3.9	7	13.7	6	11.8	1.78	29.7

Q.9. Or, (d). Hence prove that one circle cannot cut another circle at more than two points.

6

Q. 10(a) Triangle Construction Problem in Geometry

Allotted Mark	Average Score	S. D.	C. V.
5	3.1	2.15	69

Students capable of securing

29	44	54	69

on the Full Paper can score

30	50	60	80

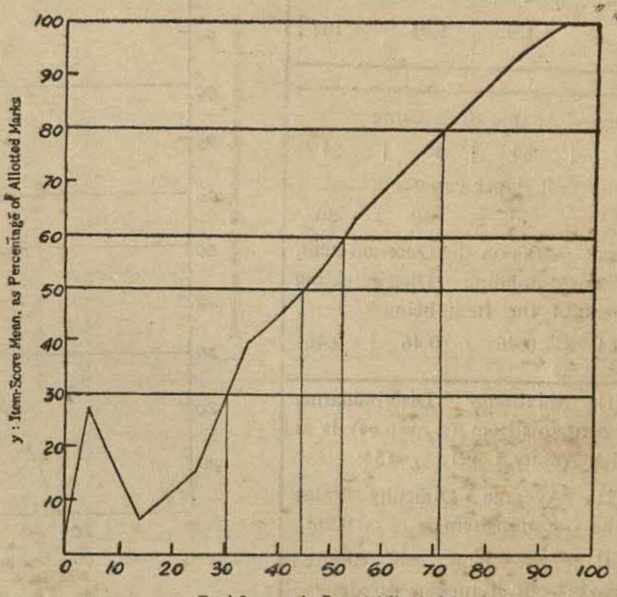
percent marks on the Question-item, the corresponding Discriminating Powers of the Item being

0.63	0.53	0.47	0.40

(I). Maximum Discriminating Power of this Item ($\delta_p = 0.63$) is at a low Ability Level ($\delta_L = 29$).

(II). Average Difficulty Value of the Question-Item is ($\delta_v = 0.63$).

(III). The item was allotted 5 marks, but it appears to deserve an Optimum of 7 marks.



Discriminating Graph for Q. 10(a) on Triangle Construction Problem in Geometry

TABLE NO. 31

Showing performances of candidates in Q.10(a), a construction problem from Geometry (Hall & Stevens - Part II)

Marks secured in the range as follows	No. of candidates for the Paper	No. of candidates attempting the Item		No. of candidates securing Marks as follows : with p.c. to total No. of attempts.												Average Marks Secured	
				0		1		2		3		4		5			
		No.	p.c. to Total	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	Actual	p.c. of Max. Marks
0–09	72	3	4.2	2	66.7							1	33.3			1.34	26.7
10–19	121	27	22.3	25	92.6							1	3.7	1	3.7	0.34	6.7
20–29	190	50	26.3	41	82.0			1	2.0	1	2.0	1	2.0	6	12.0	0.78	15:6
30–39	759	210	27.7	118	56.2	1	0.5	5	2.4	7	3.3	11	5.2	68	32.4	1.98	39.6
40–49	938	358	38.2	167	46.6	1	0.3	5	1.4	13	3.6	32	8.9	140	39.1	2.45	49.0
50–59	752	344	45.7	114	33.1			3	0.9	19	5.5	22	6.4	186	54.1	3.15	62.9
60–69	461	265	57.5	60	22.6	1	0.4	2	0.8	7	2.6	29	10.9	166	62.6	3.67	73.3
70–79	264	183	69.3	21	11.5			3	1.6	7	3.8	24	13.1	128	69.9	4.17	83.3
80–89	123	87	70.7	1	1.2					7	8.0	10	11.5	69	79.3	4.67	93.4
90–	37	24	64.9											24	100.0	5.00	100.0
Total	3717	1551	41.7	549	35.4	3	0.2	19	1.2	61	3.9	131	8.4	788	50.8	3.13	60.4
Boys (R)	3122	1321	42.3	447	33.8	3	0.2	14	1.1	51	4.0	111	8.4	695	52.6	3.23	64.6
Boys (P)	463	165	35.6	78	47.3			4	2.4	8	4.8	16	9.7	59	35.8	2.37	47.4
Girls (R)	97	52	53.6	18	34.6			1	1.9	2	3.8	3	5.8	28	53.8	3.08	61.6
Girls (P)	35	13	37.1	6	46.2							1	7.7	6	46.2	2.62	52.4
Total	3717	1551	41.7	549	35.4	3	0.2	19	1.2	61	3.9	131	8.4	788	50.8	3.13	62.6

Q.10 Either, (a). Construct a triangle having given the perimeter and two angles.(Traces of construction only are required). 5

Q. 10(b) A Locus Finding Problem in Geometry

Allotted Mark	Average Score	S. D.	C. V.
5	1.9	1.91	102

Students capable of securing

54	84	84	84

on the Full Paper can score

30	50	60	80

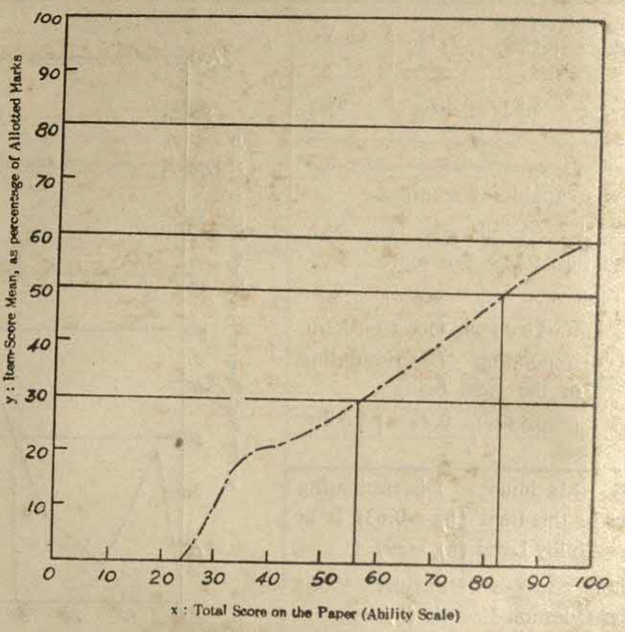
percent marks on the Question-item, the corresponding Discriminating Powers of the Item being

0.64	0.46	0.46	0.46

(I). Maximum Discriminating Power of this Item ($\delta_p = 0.64$) is at a High Ability Level ($\delta_L = 54$).

(II). Average Difficulty Value of the Question-Item is ($\delta_v = 0.96$).

(III). The item was allotted 5 marks, but it appears to deserve an Optimum of 10 marks.



Discriminating Graph for Q. 10(b) on Locus Finding Problem in Geometry

TABLE NO. 32

Appendix - B

Showing performances of candidates in Q.10(b), a construction problem from Geometry (Hall and Stevens - Part III).

Marks secured in the range as follows	No. of candidates for the Paper	No. of candidates attempting the Item (p.c. to Total)		No. of candidates securing Marks as follows : with p.c. to total No. of Attempts.												Average Marks Secured	
				0		1		2		3		4		5			
		No.	p.c. to Total	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	Actual	p.c. of Max. Marks
0–09	72	1	1.4	1	100.0											0.00	0.0
10–19	121	1	0.8	1	100.0											0.00	0.0
20–29	190	1	0.5	1	100.0											0.00	0.0
30–39	759	17	2.2	13	76.5					2	11.8			2	11.8	0.95	18.9
40–49	938	33	3.5	22	66.7			2	6.1	5	15.2	2	6.1	2	6.1	1.13	22.5
50–59	752	46	6.1	25	54.3			2	4.3	14	30.4	3	6.5	2	4.3	·1.48	29.5
60–69	461	34	7.4	16	47.1			2	5.9	10	29.4	3	8.8	3	8.8	1.80	35.9
70–79	264	54	20.5	20	37.0	1	1.9	4	7.4	15	27.8	7	13.0	7	13.0	2.17	43.3
80–89	123	47	38.2	15	31.9	1	2.1	2	4.3	12	25.5	7	14.9	10	21.3	2.53	50.6
90–	37	21	56.8	6	28.6					6	28.6	3	14.3	6	28.6	2.86	57.1
Total	3717	255	6.9	120	47.1	2	0.8	12	4.7	64	25.1	25	9.8	32	12.5	1.87	37.5
Boys (R)	3122	223	7.1	106	47.5	2	0.9	10	4.5	54	.24.2	22	9.9	29	13.0	1.87	37.4
Boys (P)	463	17	3.7	8	47.1					5	29.4	2	11.8	2	11.8	1.94	38.8
Girls (R)	97	13	13.4	5	38.5			2	15.3	4	30.8	1	7.7	1	7.7	1.92	38.4
Girls (P)	35	2	5.7	1	50.0					1	50.0					1.50	30.0
Total	3717	255	6.9	120	47.1	2	0.8	12	4.7	64.	25.1	25	9.8	32	12.5	1.87	37.5

Q.10, Either, (b). Find the locus of the vertices of isosceles triangles standing on a given base.

Q· 10(c) A Triangle Inscribing Problem in Geometry

Allotted Mark	Average Score	S. D.	C. V.
10	**4.8**	**4.24**	**88**

Students capable of securing

49 | 69 | 74 | 76

on the Full Paper can score

30 | 50 | 60 | 80

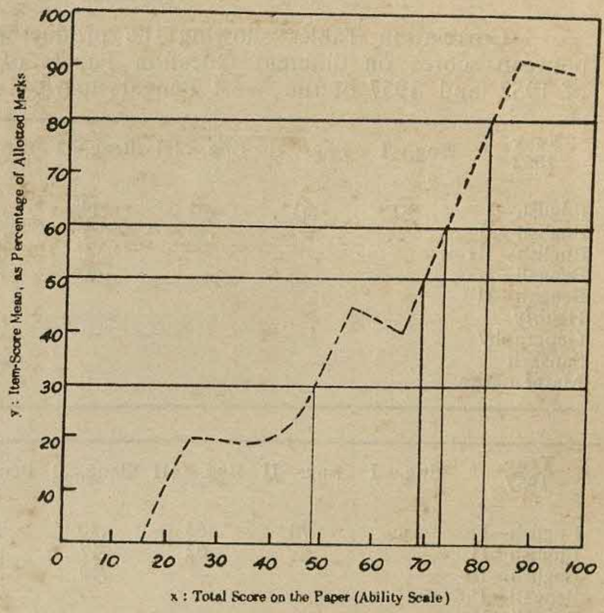
percent marks on the Question-item, the corresponding Discriminating Powers of the Item being

0.68 | 0.59 | 0.56 | 0.54

(I). Maximum Discriminating Power of the Item ($\delta_p = 0.68$) is at a Moderate Ability Level ($\delta_L = 49$).

(II). Average Difficulty Value of the Question-Item is ($\delta_v = 0.91$).

(III). The item was allotted 10 marks, and it appears to deserve an Optimum of also 10 marks.



Discriminating Graph for Q. 10(c) on Inscribing a Triangle Problem in Geometry

TABLE NO. 33

Appendix - B

Showing performances of candidates in Q.10(c) on Inscribing a Triangle in the School Final Compulsory Mathematics Paper, 1952.

Marks secured in the range as follows	No. of candidates for the Paper	No. of candidates attempting the Item (p.c. to Total)		No. of candidates securing marks as follows : with p.c. to total No. of attempts.																								Average Marks Secured	
				0		1	2	3		4		5		6		7		8		9		10			
		No.	p.c. to Total	No.	p.c.			No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	No.	p.c.	Actual	p.c. of Max. Marks
0–09	72	3	4.2	3	100.0																			0.00	00.0
10–19	121	2	1.7	2	100.0																			0.00	00.0
20–29	190	3	1.6	2	66.7									1	33.3									2.00	20.0
30–39	759	30	4.0	22	73.3							2	6.7	3	10.0			1	3.3			2	6.7	1.87	18.7
40–49	938	32	3.4	20	62.5			1	3.1			2	6.3	5	15.6	1	3.1					3	9.4	2.50	25.0
50–59	752	33	4.4	13	39.4							2	6.1	9	27.3			2	6.1	2	6.1	5	15.1	4.48	44.8
60–69	461	45	9.8	21	46.7			1	2.2	1	2.2	2	4.4	7	15.6	1	2.2	3	6.7	2	4.4	7	15.6	3.96	39.6
70–79	264	36	13.6	8	22.2					1	2.8			7	19.4			2	5.6	7	19.4	11	30.6	6.53	65.3
80–89	123	32	26.0							1	3.1			3	9.4	1	3.1	2	6.3	4	12.5	21	65.6	9.09	90.9
90–	37	12	32.4									1	8.3	1	8.3			2	16.7			8	66.7	8.92	89.2
Total	3717	228	6.1	91	39.9			2	.0.9	3	1.3	9	4.0	36	15.8	3	1.2	12	5.3	15	6.6	57	25.0	4.83	48.3
Boys (R)	3122	188	6.0	71	37.8			2	1.1	2	1.1	7	3.7	34	16.1	2	1.1	7	3.7	14	7.5	49	26.1	4.99	49.9
Boys (P)	463	17	3.7	12	70.6					1	5.9					1	5.9	1	5.9			2	11.8	2.29	22.9
Girls (R)	97	17	17.5	4	23.5							1	5.9	1	5.9			4	23.5	1	5.9	6	35.3	6.59	65.9
Girls (P)	35	6	17.1	4	66.7							1	16.7	1	16.7									1.83	18.3
Total	3717	228	6.1	91	39.9			2	0.9	3	1.3	9	4.0	36	15.8	3	1.3	12	5.3	15	6.6	57	25.0	4.83	48.3

Q. 10, Or, (c). In a given circle inscribe a triangle, equiangular to a given triangle.
10

Appendix—C

Correlation Tables showing the product-moment correlation co-efficients between scores on different Question Papers of the School Final Examination of 1952 and 1957 of the West Bengal Board.

Year 1952	Eng.–I	Eng.–II	Eng.–III	Beng.–I	Beng.–II	Hist.	Geo-graphy	Classics [Sans.]	Maths.
English–I	–	.61	.51	.44	.51	.45	.37	.56	.47
English–II		—	.46	.43	.52	.44	.37	.51	.42
English–III			—	.32	.36	.34	.27	.42	.32
Bengali–I				—	.49	.44	.34	.49	.35
Bengali–II					–	.46	.39	.56	.46
History						—	.41	·44	.38
Geography							—	.41	.44
Sanskrit								—	.51
Mathematics									—

Year 1957	Eng.—I	Eng.—II	Eng.—III	Beng.—I	Beng.—II	Hist.	Geo-graphy	Classics [Sans.]	Maths.
English—I	–	.70	·65	.30	.49	.53	.48	.57	.57
English—II		—	.62	.47	.48	.49	.45	.53	.51
English—III			—	.40	.42	.47	.43	.48	.46
Bengali—I				—	.49	.47	·36	.50	.41
Bengali—II					—	·42	.41	.52	.43
History						—	.47	.51	.44
Geography							—	.49	.56
Sanskrit								—	.58
Mathematics									—

The two tables showing the correlation matrix of scores on the nine different examination papers of the School Final Examination, West Bengal, for the years 1952 and 1957 respectively, have been prepared with a view to find out (*i*) a single ranking index that best discriminates between students according to their merit and (*ii*) whether there exists any hierarchy in the set of papers regarding measurement of students' ability, and if so whether it remains stable from year to year. [A study on these points by A. K. Gayen and R. K. Mathur will appear elsewhere].

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GLOSSARY

Ability Level : Ability of a candidate in a subject is measured by his aggregate score, which ranges from 0 to 100 or multiple of 100. The numerical value of the score represents the Ability Level.

Bar Diagram : The diagrammatic representation of frequencies of any attribute by bars proportional in length to their magnitudes for the sake of comparative study.

Bias and Biased Samples : Bias is a tendency to err in one direction. Its influence gives rise to biased samples ; that is, the samples which are not representative of the population.

Biserial Correlation Coefficient : A coefficient of correlation of two variables, one being a measurable variate and the other dichotomous. One variable falls into many classes or categories and another into just two categories.

Bivariate Distribution : The distribution of a pair of variates, such as score in Mathematics and that in History, score in one question-item and score in the total of a paper etc.

Coefficient of Correlation : A measure of relationship between two variates. Its value ranges from -1 to $+1$ through 0. The values -1, 0, $+1$ correspond respectively to absolute negative, nil and absolute positive relationship between the variates.

Conceptual Analysis : Analysis of the test items in respect of concepts introduced in the syllabus. The analysis keeps in view the knowledge and the application aspects of a concept.

Criterion : A standard by which a test is to be judged for its efficiency.

Cumulative Frequency : The successive summing up of the class frequencies.

Diagnostic Value of a Test : The quality of a test in measuring the deficiency of knowledge in a subject.

Dichotomy (*Dichotomize*) *:* A division of a population or a sample into two groups.

Difficulty Value of a Test : It is measured by the incorrect responses or no response at all to a test.

Discriminating Curve : The curve obtained by plotting the corresponding item score averages at all the aggregate score points.

Discriminating Power of a Test-item : A quality of the test-item in revealing, through the responses to it, a sharpness of distinction amongst the examinees at different ability levels.

Dispersion of Scores : The manner in which scores of candidates on an item or in a paper are scattered over the entire range of the allotted mark on the item or the full marks on the paper.

Error of Estimate : The difference between the true score and its estimate.

Evaluation : An overall estimation of students' integrated whole, before and after a course of education in respect of their expected behaviourial changes.

Examination : An examination is an educational activity by which schools, colleges or universities and other Bodies test the students with a set of questions or problems on a prescribed syllabus for the purpose of ranking them in order of merit.

Factor : Some basic element present in several variables and hence a 'factor' of variation in the set of variables.

Factor Analysis : An analysis of the inter-relationships of a set of variables leading to the determination of the variables in terms of a number of basic elements or factors and a residual expression.

Fractile (Percentile, Decile) : It denotes the variate value below which lies a given fraction of the cumulative frequency. This term is synonymous with the more generally used term quantile, which means the class of $(n-1)$ partition values of a variate which divide the total frequency of population or a sample into a given number n of equal proportions. For example, if $n=4$, then $n-1$ values are the quartiles; if $n=10$, then $n-1$ values are the deciles, as we have come across in our analysis of marks to determine the discriminating power.

Frequency Distribution : A tabulation of the frequencies of different scores or groups of scores when they are arranged in order and shown against the different values or class intervals of the variable.

Frequency Polygon : A diagram showing the form of a frequency distribution ; the frequencies are graphed as ordinates against the variate values as *abscissae* and the tops of the *ordinates* are joined one to the next.

Histogram : A univariate frequency diagram in which rectangles proportional in area to the class frequencies are erected on sections of the horizontal axis, the width of each section representing the corresponding class interval of the variate.

Item Analysis : Any statistical analysis of item scores of candidates to determine its (*i*) appropriateness, (*ii*) power of discrimination, (*iii*) difficulty value, (*iv*) suitability from the view point of syllabus, (*v*) reliability and (*vi*) validity.

Kuder-Richardson Formula : It is a formula for estimating the reliability co-efficient (q. v.) of the test which aims at overcoming the disadvantages of formulae associated with split-half method. Numerous forms of the formulae are available in standard books on statistics.

Mean, Median, Mode : Mean is the sum of the individual values of a variate divided by the number of individuals. The sum of the deviations of the observations above this mean is equal to the sum of the deviations of the observations below it ; also called Arithmetic mean or Average. *Median* is that value of the variate which divides the total frequency into two halves. The value of the variate possessed by the greatest number of members of a population is called the *Mode.*

Measure of Central Tendency : A value near the centre of a frequency distribution that in some way represents the entire group of scores. Measures of central tendency includes the mean, the median and the mode.

Measure of Variability : A statistical measure that shows the extent to which the individual scores are concentrated about or spread out from the mean or other measure of central tendency ; also called *measure of dispersion.*

Norm. A type of measure based on a specified sample, that assists in the interpretation of raw scores ; e. g., means, percentiles, standard scores, etc., for a specified sample.

Normal Distribution : The continuous frequency distribution of infinite range expressed in terms of the mean (μ) and standard deviation (σ), as

$$y=(1/\sigma\sqrt{2\pi})\ \exp\{-(x-\mu)^2/2\sigma^2\}$$

The curve is a bell-shaped one and agrees well with educational or psychological variables.

Optimum Mark (as distinguished from the Allotted Mark) : It refers to the value of a question-item in terms of its difficulty value to which it is directly proportional.

Parallel Tests : Two or more tests are said to be statistically parallel when the average scores, the dispersion of scores and the mutual correlations are the same.

Population : All of the members in the class of things being investigated by statistical methods, also called 'universe' in a statistical way.

Random Sample : A limited number of cases selected from a universe or population in such a way that every individual case has an equal and independent chance of being included.

Reliability : It refers to the accuracy with which a measuring device measures what it purports to measure.

Reliability Coefficient : It is a coefficient meant to assess the systematic component of a variate (test) as distinct from error components. It is usually measured by the correlation between the results of two administrations of the same test or parallel tests.

Spearman-Brown Formula :—A formula for the estimation of the reliability coefficient of a psychological or educational test which is n times as long as a basic test for which the reliabilities are known. If r_1 is the reliability of a test of unit length, the reliability of a test of length n is $nr_1/[1+(n-1)r_1]$.

Standard Deviation and Variance : A measure of variability obtained by taking the square root of the mean of the squares of the deviations of the scores from their mean. The square of standard deviation is known as variance.

Stratified Sample : A sample selected by dividing a large population or universe into smaller homogeneous stratum on the basis of the characteristic considered, and by taking a proportional number of cases from each stratum, when the samples are taken at random out of each stratum.

Tetrachoric Correlation : An estimate of the product moment correlation between the normally distributed variates, obtained from the information contained in a two-by-two table.

True Score : The value of a score or statistical measure entirely free from error.

Validity : The extent to which a test or other variables measures what it purports to measure. Validity is often measured by the correlation of the variable with a criterion. This correlation is called validity coefficient.

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Rarely does a research undertaking turn out exactly as originally planned and this study is no exception. The available mathematical theory and statistical methods for interpretations of test results generally assume an objective nature of test material in which answer to a test-item is either correct or incorrect (two point scale). But the question-items set in our public examinations are generally of the essay type and allow of grading the responses to them on more than two point scale (in fact in many point scales depending on the allotted marks on the items) and do not, therefore, yield to analysis by the available statistical formulae. Thus knowing full well that the existing statistical methods, although useful for interpretation and analysis of objective types of test results, may not prove efficient in the analysis of results of large scale public examinations, we set before us in the beginning, an objective of developing suitable techniques for studying problems such as the difficulty values, discriminating powers, reliability and validity of the essay type of questions. We developed certain quantitative rationale for achievement testing and some of the results obtained were published in 1958 in the Journal of Education and Psychology, Baroda, India, and earlier in 1954 in mimeographed form as prepublication draft. This theoretical and somewhat academic pursuit was motivated by a desire to find out how far causes of the vagaries of public examinations could be traced through statistical analysis of the performance records of the students taking the internal or external examinations.

But some of the practical aspects in our reported studies on correlational analysis of the four factors of examinations namely, (i) the syllabus (what is taught), (ii) the method of teaching (how it is taught), (iii) the question paper and the answer script (what is examined) and (iv) the methods of assessment of candidates' performances (how it is examined), attracted attention of Dr. J. C. Ghosh, the then Vice-Chancellor of the University of Calcutta ; Principal A. K. Chanda, the then President, Board of Secondary Education, West Bengal ; Principal A. N. Basu of the Central Institute of Education and others. They said, statistical analysis of this kind regarding the present system of examinations is undoubtedly useful in basing decisions for the future development of the programme of reforms in our country, and encouraged us to take up a long term survey and research on other important subjects such as English, Bengali, History and Geography. They further observed that a Five-Year Scheme of Research on Examinations was well worth undertaking for the study of achievements in these subjects. Accordingly, in 1955 myself and Dr. P. K. Bose, Head of

the Department of Statistics, Calcutta University, submitted a Scheme of Research on Examinations to the Ministry of Education, New Delhi, for their approval and financial support. The Ministry of Education approved our scheme and sanctioned necessary financial grant in November 1956, and an Advisory Committee was formed in January 1957 to help and guide the work of the Project. At the first meeting of the Committee in February 1957, it was decided that the draft on Mathematics should serve as a model for studies in other subjects and that we should undertake further improvement of the draft for publication as Report No. I of the Research Project.

I may note here that in the year 1952, I thought of doing some independent research work in the field of education and examination and approached the Board of Secondary Education, West Bengal, with a request to give me facilities for collection of necessary and relevant data regarding the Board's Examination of that year. Early in 1954 when I joined the Mathematics Department of the Indian Institute of Technology, Kharagpur, I started writing the first draft of our studies on Mathematics in collaboration with P. B. Nanda, N. Bhattacharyya and Satya D. Dubey. During 1957-58, when this draft was being improved and prepared in final form for the press R. K. Mathur and P. Duari joined us as collaborators. Also R. Mazumdar assisted us in preparing some of the sections on evaluation and examination ; M. Roychoudhuri, A. P. Bose and G. D. Koyal gave assistance in preparing certain material on the reliability and standardisation of tests. G. C. Roy helped us a good deal in preparing a considerable portion of the Parts IX to XII. The conceptual analyses of the two question papers on Mathematics are largely his contributions. He supervised the work of printing and proof-reading of a good portion of our scripts. In our project office, Surath C. Roy and Subhas Chatterjee have put in hard work in connection with mechanical (IBM/Hollerith) tabulation and manual computation of data.

* * * * *

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* * * * *

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